

7 Inadequate assessment of natural climate variability

The GCRA includes a statutory requirement that “analyzes current trends in global change, both human-induced and natural, and projects major trends for the subsequent 25 to 100 years.” This statement makes a specific requirement to address natural climate variability as well as human-induced change. The CWG25 Report emphasized the importance of natural variability in understanding the causes of recent change, including global warming, impact drivers and extreme weather events.

7.1 Ignoring and dismissing natural climate variability

In the Physical Science chapters (2 and 3), natural variability is mentioned briefly in Chapter 2 only to dismiss its importance. Chapter 2 does not even mention natural variability in the Uncertainties and Research Gaps section of Traceable Accounts. Chapter 3 includes discussions of natural processes but dismisses their importance in the attribution of global warming; meaningful discussion of natural variability is included only in Key Message 3.4.

Of the sectoral chapters, only 4 (Water), 9 (Coastal Effects) and 10 (Ocean Ecosystems and Marine Resources) at least acknowledge the background of natural variability. Natural variability is almost entirely ignored in the Uncertainties and Research Gaps section of Traceable Accounts.

In the regional chapters (21-30) where one would expect considerable analysis of the impacts of natural climate variability, only the chapters on the Caribbean and Hawaii provided a meaningful discussion, with the chapters on Midwest, Northwest and Alaska providing no discussion at all. The existence of a high background of natural variability was mentioned without further analysis in chapters 25 (Northern Great Plains), 26 (Southern Great Plains), and 28 (Southwest).

Chapter 15 on Tribes and Indigenous Peoples includes the following statement in the Introduction: “Many Indigenous persons closely track natural cycles and assemblages of plants and animals, making them keenly aware of environmental disruptions.” However, there is no further mention of anything related to natural climate variability in the remainder of the chapter.

7.2 Conflation of natural and anthropogenic climate change

NCA5’s Glossary defines “climate change” as a change in climate for any reason. This is technically correct, but at variance with the (now) popular perception of all climate changes being anthropogenic. The distinction is not academic – it is central both to attribution questions and to projections, since anthropogenic changes would respond to mitigation while natural changes are unavoidable.

The discussion on NCA5 page 2-4 begins “Human activities are changing the climate”, then goes on to list evidence for anthropogenic GHG emissions and climate warming. The next paragraph begins “Climate change is happening now in the United States. Including Alaska, the continental US has been warming about 60% faster than the planet as a whole since 1970.” In context the implication is that the warming of CONUS faster than the planetary average is an effect of GHG emissions. But it is an artifact of the Earth’s surface being 70 percent ocean. Since the ocean warms more slowly than land, comparison of any land surface outside the tropics with the global average would show the land surface to be warming faster than the global average, regardless of the cause of the warming.

The same page goes on to say “Climate change is already affecting people in the United States. Extreme heat was estimated to be responsible for more than 700 deaths per year between 2004 and 2018 although some estimates put heat-related mortality closer to 1,300 deaths annually.” But extreme heat, whether naturally-caused or not, has always been a risk to human health. As to trends, the data show that adaptation has caused the mortality burden of extreme heat to drop substantially in recent decades (CWG25 Section 10.3.1).

Consider also the NCA5 statement on precipitation that we cited in Section 3.2:

Many eastern regions of the country are getting wetter (Figure 2.4). Average annual precipitation from 2002-2021 was 5%-15% higher relative to the 1901-1960 average in the central and eastern US, a trend attributable to climate change.

The attribution is superfluous because the statement is a tautology by NCA5’s definition of climate change. But its gratuitous inclusion effectively attributes the observed trend to greenhouse gas emissions.

Exploitation of the ambiguity in “climate change” is endemic to NCA5. The NASEM review (pp. 23-24) ~~NEED QUOTES FROM NASEM~~ commented on this problem, and it could have been easily addressed by adopting the phrase “changing climate” for general changes while reserving the term “climate change” for anthropogenic changes. But the NCA5 authors seemingly ignored their recommendation.

A separate but related issue is use of the term “climate change” to refer to increases in socioeconomic vulnerabilities that have anthropogenic but non-GHG-related causes. NCA5 page 1-19 states “Climate change exacerbates inequalities.” But the issue discussed is the negative correlation between neighborhood-level income and land surface temperatures (LST) in urban areas. To the extent the correlation is real, the most likely explanation is that low-income households concentrate where housing is less expensive, which may be in neighborhoods with less nearby parkland and tree cover, which has nothing to do with CO₂ emissions. Similarly the NCA5 makes repeated reference to the Billion Dollar Disaster dataset which is dominated by trends in population and economic growth rather than climate change, as discussed in CWG25 Section 10.2.

DOCUMENT WITHHELD FOR PRIVILEGE

DOCUMENT WITHHELD FOR PRIVILEGE

DOCUMENT WITHHELD FOR PRIVILEGE

DOCUMENT WITHHELD FOR PRIVILEGE

DOCUMENT WITHHELD FOR PRIVILEGE

DOCUMENT WITHHELD FOR PRIVILEGE

DOCUMENT WITHHELD FOR PRIVILEGE

DOCUMENT WITHHELD FOR PRIVILEGE

DOCUMENT WITHHELD FOR PRIVILEGE

DOCUMENT WITHHELD FOR PRIVILEGE

DOCUMENT WITHHELD FOR PRIVILEGE

DOCUMENT WITHHELD FOR PRIVILEGE

DOCUMENT WITHHELD FOR PRIVILEGE

From: Ross McKittrick <ross.mckittrick@gmail.com>
Sent: Tuesday, April 29, 2025 7:20 PM
To: Steven Koonin; John Christy; Roy W. Spencer; Travis Fisher; Judith Curry
Subject: April 29 update
Attachments: 1 CO2.v.CACs.April29.docx; 0.Front.matter.Apr29.docx; 4.AnthropogenicRF.Apr29.docx

I've created a Dropbox folder called 00.Report Draft where I am hoping we can accumulate current drafts of each chapter (the 00. prefix keeps it at the top of the list).

In the Front Matter file I've put the Table of Contents as best I understand it, with the various additions we've discussed. Also I've put current drafts of chapters 1 and 4, the latter which includes my stab at aerosols. These files are in the Dropbox and attached.

This evening or tomorrow morning I'll populate the folder with the most recent versions of all the other chapters i have. Feel free to do likewise.

1 Carbon dioxide as distinct from criteria air contaminants

This report is chiefly concerned with carbon dioxide (CO₂) emissions from fossil fuel use. Although it has become common to refer to CO₂ as “pollution” this is a misnomer. In the framework of United States clean air policy there are six types of so-called Criteria Air Contaminants (EPA, undated): particulate matter, ground-level ozone, Sulfur Dioxide, Nitrogen Dioxide, Lead and carbon monoxide (CO). Air contaminants are subject to regulatory control because they cause local problems depending on concentrations that include nuisances (odor, visibility problems), damage to plants and, at high enough exposure levels, toxicological effects in humans.

CO₂ has not historically been viewed as an air pollutant in the US or elsewhere because it is odorless, does not affect visibility and has no toxicological effects at ambient levels. It is a naturally-occurring part of the atmosphere and a key component of human and plant respiration. CO₂ is essential for plant photosynthesis and higher levels are generally considered beneficial for vegetation, as will be discussed in this report.

Ambient outdoor air contains about 420 parts per million (ppm) CO₂. The US Occupational Safety and Health Administration issues guidelines for indoor workplaces in which elevated CO₂ may be encountered, such as where dry ice is used. The Permissible Exposure Limit is 5,000 ppm over 8 hours (OSHA 2024). Allen et al. (2015) reported evidence of diminished performance on some cognitive tasks among workers in office cubicles when exposed to CO₂ levels above 1,000-1,500 ppm.

The main concern about CO₂ is its potential effects on the global climate. This is a very complex question which will occupy much of this report. We will begin in the next section by looking at the role of CO₂ in promoting global greening and agricultural productivity growth, then we will examine the effect of CO₂ on ocean alkalinity. We then turn to CO₂'s role as a so-called greenhouse gas (GHG), beginning with a brief description of radiative forcing, the carbon cycle and the role of aerosols. Part II of this report discusses in detail the topic of the climatic response to GHGs. Part III discusses some aspects of the impacts of climate change on ecosystems and society.

US Environmental Protection Agency (Undated) Criteria Air Pollutants. <https://www.epa.gov/criteria-air-pollutants> accessed April 29 2025.

US Occupational Health and Safety Administration (2024) “OSHA Occupational Chemical Database: Carbon Dioxide” <https://www.osha.gov/chemicaldata/183>

Allen, Joseph G, Piers MacNaughton, Usha Satish, Suresh Santanam, Jose Vallarino and John D.S. Spengler (2015) Associations of Cognitive Function Scores with Carbon Dioxide, Ventilation, and Volatile Organic Compound Exposures in Office Workers: A Controlled Exposure Study of Green and Conventional Office Environments. *Environmental Health Perspectives* 124(6) pp. 805-812 <https://doi.org/10.1289/ehp.1510037>

Report of the Special Advisory Group on Carbon Dioxide and Climate Change

Submitted to the Secretary, US Department of Energy

May 30, 2025

John Christy, Ph.D.
Judith Curry, Ph.D.
Steven Koonin, Ph.D.
Ross McKittrick, Ph.D.
Roy Spencer, Ph.D.

Table of Contents

Secretary's Preface

Introduction: Overview and purpose of document

Part I: Direct human influence on ecosystems and the climate

- 1 Carbon dioxide as distinct from criteria air contaminants
- 2 Global greening and CO₂ fertilization
- 3 Ocean Alkalinity
- 4 Anthropogenic Radiative forcing
 - 4.1 Components of anthropogenic radiative forcing and their history to date
 - 4.2 The carbon cycle and future emission scenarios
 - 4.3 Aerosols and the uncertainties associated with them

Part II: Climate response to greenhouse gas emissions

- 5 Measuring climate sensitivity to CO₂ doubling
- 6 Models versus observations in recent past
- 7 Uncertainties in analysis of attribution
- 8 Evidence on trends and attributable changes in extreme weather
- 9 Sea level rise

Part III: Impacts on ecosystems and society

- 10 Climate change and US agriculture
- 11 Managing risks of extreme weather
- 12 Mortality risk from extreme heat and cold
- 13 Climate change and the Economy
 - 13.1 The Social Cost of Carbon
 - 13.2 Climate change and economic growth
- 14 US vehicle-based CO₂ emissions and the global climate

References

4 Anthropogenic Radiative Forcing

4.1 Components of anthropogenic radiative forcing and their history to date

4.1.1 Historical radiative forcing

A changing climate has been the norm throughout the Earth's 4.6-billion-year history. The Earth's temperature and weather patterns change naturally over timescales ranging from decades to millions of years. Natural variations in the surface climate originate in two ways. Internal climate fluctuations associated with circulations in the atmosphere and ocean produce exchanges of energy, water, and carbon between the atmosphere, oceans, land, and ice. External influences on the climate system include variations in the energy received from the sun and the effects of volcanic eruptions. Human activities influence climate through changing land use and land cover. Humans are also changing atmospheric composition by increasing the emissions of CO₂ and other greenhouse gases and by altering the concentrations of aerosol particles in the atmosphere.

The earth is warmed by the sunlight it absorbs and cooled by the radiative heat it emits to outer space. Averaged over Earth, each of these processes involve power flows of about 240 Watts per square meter (W/m²). When they are in balance, there are no net external causes of warming or cooling. Human (and some natural) influences on the climate alter this balance and so cause the climate to change.

Influences on the energy balance are quantified by "radiative forcing", the extent to which they disturb the warming/cooling balance; a positive forcing warms while a negative forcing cools. The IPCC's estimated history of major components of radiative forcing since 1750 is shown in the following two figures from the IPCC AR6.

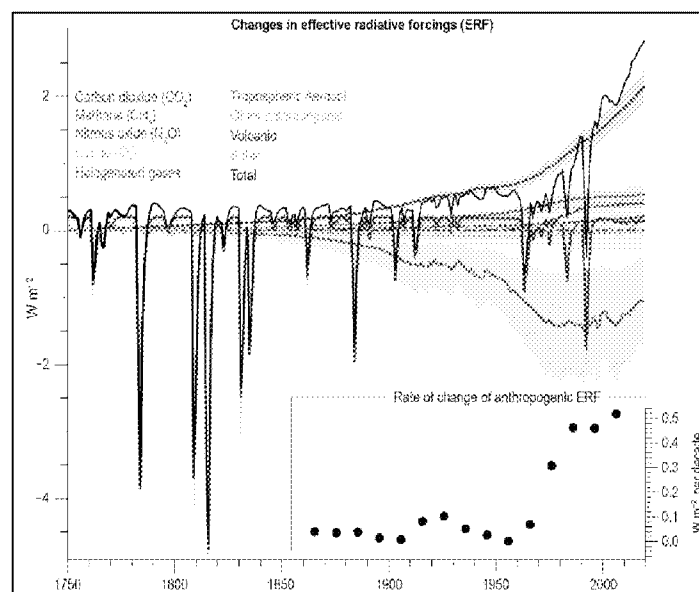


Figure 4.1.1: IPCC estimates of radiative forcing components over time. Source: <https://www.ipcc.ch/report/ar6/wg1/figures/chapter-2/figure-2-10/>

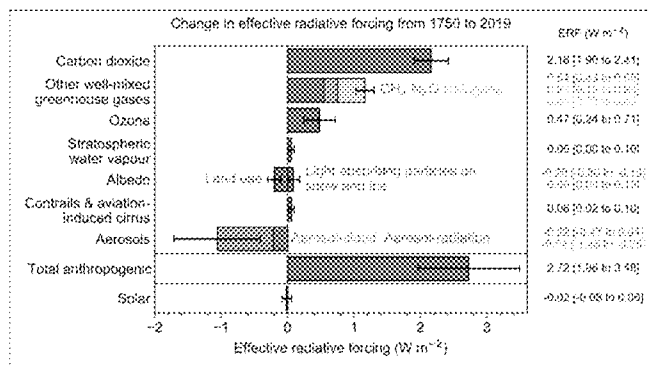


Figure 4.1.2 IPCC estimates of radiative forcing component changes from 1750 to 2019. Source: <https://www.ipcc.ch/report/ar6/wg1/figures/chapter-7/figure-7-6/>

These graphs show that the total radiative forcing is comprised of natural and anthropogenic components. Carbon dioxide is the largest human influence on the climate and the one most relevant to the effects of energy-using systems like motor vehicles. Its emissions are accumulating in the atmosphere, as described in the following section. It exerts a warming influence by decreasing the cooling power of the atmosphere. Other greenhouse gases (methane, nitrous oxide, halogens, and ozone), which act similarly, currently add another 75% to CO₂'s warming. Aerosols exert a cooling effect, although with large uncertainties in the way they catalyze the formation of reflective clouds. As a result, understanding of the causes of recent warming requires not just identifying the warming effects of CO₂, but also the more uncertain cooling effects of sulfate aerosols.

The IPCC views the role of the sun as negligible, based on their preference for reconstructions that imply minimal solar change since preindustrial times. Connolly et al. (2021) review 16 different Total Solar Irradiance (TSI) reconstructions in the literature covering the 1600-2000 interval which vary in their implications from almost no change in TSI to a relatively large upward trend. They point out that the variation in TSI reconstructions combined with variations in surface temperature reconstructions implies pairings can be found that are consistent with either no or most 20th century warming being attributable to the sun. A particularly thorny issue is the gap in the TSI data between 1989 and 1991 due to a delay in the launch of a monitor after the Space Shuttle Challenger disaster on January 28 1986, which prevented a replacement satellite from being launched in time to overlap with, and its readings to be intercalibrated with, the prior system (Zacharias 2014, Scafetta et al. 2019). The question of whether there is an upward trend

in TSI over 1978 to 2018 comes down to how the missing data in that gap are filled. That being the case it is noteworthy that Zacharias (2014) observes the solar research community has been motivated by a desire to downplay any potential role of the sun in climate change so as not to detract from arguments for greenhouse gas abatement:

A conclusive TSI time series is not only desirable from the perspective of the scientific community, but also when considering the rising interest of the public in questions related to climate change issues, thus preventing climate skeptics from taking advantage of these discrepancies within the TSI community by, e.g., putting forth a presumed solar effect as an excuse for inaction on anthropogenic warming.

(Zacharias 2014)

The other natural forcing component is largely volcanic aerosols, which exert an episodic cooling effect.

The anthropogenic forcing component was negligible before about 1900 and has increased steadily since, rising to almost 3 W/m² today. However, this is still only about 1 percent of the unperturbed radiation flows, making it a challenge to isolate the effects of anthropogenic forcing since state-of-the-art satellite estimates of global radiative energy flows are only accurate to a few Watts per sq. meter. Natural sources of global energy imbalance other than volcanoes are not included in these graphs because they remain largely unknown.

4.1.2 Future radiative forcing

Carbon dioxide's warming influence depends upon how much "extra" CO₂ accumulates in the atmosphere- i.e., its concentration. The CO₂ level as recorded at the Mauna Loa observatory in Hawaii is generally used as the representative global average concentration. The data are available online at <https://gml.noaa.gov/ccgg/trends/index.html>. The concentration was about 316 ppm at the start of the record in 1959 and is now about 425 ppm, a 34 percent increase.

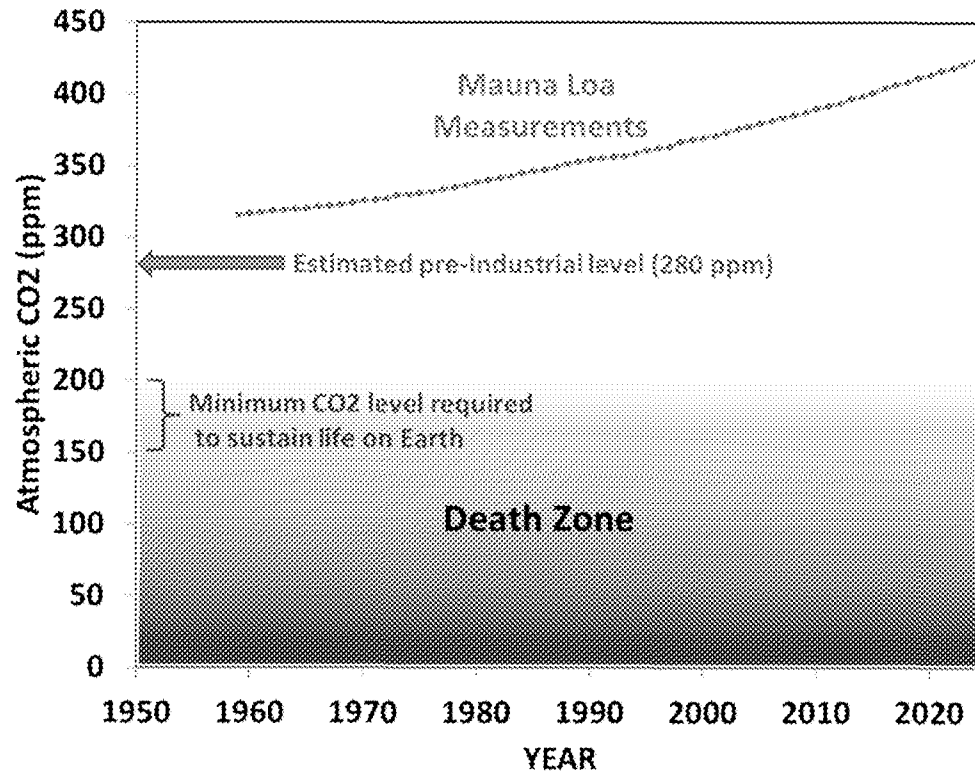


Fig. 4.1.3 Yearly average atmospheric CO2 concentrations (1959-2024) measured at Mauna Loa, HI (green) compared to the estimated pre-Industrial CO2 concentration of 280 ppm, and the estimated minimum levels required to sustain life on Earth (150 to 200 ppm). Need source

The annual increase in concentration is only about half of the CO2 emitted because land and ocean processes absorb “excess” CO2 at a rate approximately 50% of human emissions. Thus, future concentrations, and hence future human influences on the climate, depend upon two components: (1) future rates of global human CO2 emissions, and (2) how fast the land and ocean remove extra CO2 from the atmosphere. We discuss each of these in turn.

4.2 The carbon cycle and future emission scenarios

4.2.1 Emission scenarios

Assessing the future dangers of GHG emissions requires assumptions about what those emissions will be. Future emissions, and hence human influences on the climate, will depend upon future

demographics, economic progress, regulation, and the energy and agricultural technologies in use. Various assumptions about each of those lead to projections of greenhouse gas emissions and concentrations, aerosol concentrations, and changes in land use, which ultimately can be combined into assumptions about anthropogenic radiative forcing.

Because of the great uncertainties about the decades to come, instead of making precise predictions of future concentrations, the IPCC has created various sets of scenarios meant to span a plausible range of possibilities for population, economy, technology, and so on. Recent versions of the scenarios are labeled by a number indicating the anthropogenic radiative forcing expected in 2100 under that scenario. Thus, a scenario labeled with a “6” corresponds to 6 W/m² of human-induced radiative forcing (warming) at the end of the century. (Recall current anthropogenic radiative forcing is about 2.7 W/m².)

Although the IPCC does not put its emission scenarios forward as forecasts they are often treated as such. Comparisons of past scenario groups against observations shows a tendency for IPCC emission projections to overstate actual subsequent emissions. For the IPCC Third and Fourth Assessment Reports a set of emission projections from the *Special Report on Emission Scenarios* were used, and hence were referred to as the SRES scenarios. McKittrick et al. (2012) showed that, when converted to per capita terms, the SRES scenario distribution was skewed upwards and incompatible with observed trends. McKittrick and Wood (2013) further showed that global energy market dynamics constrained global per capita CO₂ emissions to an extent not reflected in IPCC scenarios. The bias of the SRES scenarios was confirmed by the later analysis in Hausfather et al. (2019) who showed that observed atmospheric CO₂ concentrations tracked the low end of the SRES range.

For the Fifth Assessment Report the IPCC developed a new set of scenarios called the Representative Concentration Pathways (RCP). These were identified by a number representing the increase in forcing and were thus called RCP2.6, RCP4.5, RCP6.0 and RCP8.5. RCP2.6 (implying a gain of 2.6 Watts per square meter) projects a GHG concentration pathway which implies warming remains well below 2°C. At the other end of the scale RCP8.5 is an extreme outcome implying nearly 5°C warming just in this century.

In both the academic literature and popular media RCP8.5 came to be referred to as the no-policy baseline, or “business-as-usual” scenario. It was used in this way to generate the reference outcome supposedly representing the 21st century world in the absence of emission reduction policies. But RCP8.5 was intended as a low-probability high emissions scenario and its usage as a business-as-usual baseline has been criticized as grossly misleading. Hausfather and Peters (2020) writing in a commentary in *Nature* magazine, pointed out that RCP8.5 was developed as an extreme worst-case, and its misuse as a “business as usual” baseline has resulted in a large number of misleading studies and media reporting:

RCP8.5 was intended to explore an unlikely high-risk future. But it has been widely used by some experts, policymakers and the media as something else entirely: as a likely ‘business as usual’ outcome. A sizeable portion of the literature on climate impacts refers to RCP8.5 as business as usual, implying that it is probable in the absence of stringent climate mitigation. The media then often amplifies this message, sometimes without communicating the nuances. This results in further confusion regarding probable emissions outcomes, because many climate researchers are not familiar with the details of these scenarios in the energy-modelling literature.

(Hausfather and Peters 2020)

The implausibility of the RCP8.5 scenario was examined by Burgess et al. (2021). They noted that RCP8.5 has already diverged from observed energy use trends, and the near future trends diverge sharply from those of the International Energy Agency (IEA) which provides market-based projections of energy use for coming decades. IEA trends are based on plausible extrapolations of current economic and demographic trends, and the results run below the entire envelope of RCP projections, implying not only that RCP8.5 is dubious, but even lower emission scenarios are looking unlikely. Burgess et al. comment (p. 8):

Beyond 2040, if the trends anticipated by energy agency forecasts continue, carbon intensity will continue diverging from AR5 and SSP baselines—especially from higher-emission scenarios such as RCP8.5, due to the assumptions about fossil-fuel expansion in these scenarios that are increasingly implausible.

Widespread use of RCP8.5 has caused a bias towards alarmism in the climate impacts literature. The extent of this problem was confirmed in a literature analysis by Pielke Jr. and Ritchie (2020). They found (p. 32) that between 2010 and 2020 some 16,800 scientific papers had been published using the RCP8.5 scenario, and (p. 16) that about 4,500 of the articles linked RCP8.5 with the concept of “business-as-usual”. They provided analyses of how RCP8.5 was misused not only by individual researchers, but by influential science agencies like the IPCC and the US National Climate Assessment (USNCA), which has directly led to misleading coverage in prominent media outlets. They provide the following example (p. 30):

The USNCA employed RCP8.5 as a baseline scenario, despite warning against such use, and compared it to RCP4.5 throughout its report to generate quantitative economic estimates of the benefits of mitigation. In a front-page story, the *New York Times* promoted the report’s misuse of RCP8.5 as a baseline scenario:

“A major scientific report issued by 13 federal agencies on Friday presents the starkest warnings to date of the consequences of climate change for the United

States, predicting that if significant steps are not taken to rein in global warming, the damage will knock as much as 10 percent off the size of the American economy by century's end."

Pielke and Ritchie (2020) reported new studies using RCP8.5 were appearing in the literature at a rate of about 20 per day, with about two per day specifically linking RCP8.5 and "business as usual." They conclude (p. 34) that the climate research community has spent a decade "committing scientific resources to science fiction" (emphasis added):

"Derived estimates from RCP8.5 as "business as usual" such as future climate impacts, the impacts avoided from mitigation and the cost effectiveness and benefits of mitigation have no real-world meaning... **The scientific literature has become imbalanced in an apocalyptic direction.**

(Pielke Jr. and Ritchie p. 34)

The IPCC later converted the RCP scenarios to the "Shared Socioeconomic Pathway" or SSP scenarios, but these have continued the pattern of bias shown with the RCP and SRES scenarios. Figure 3.1.4 was generated using the Resources for the Future Global Energy Outlook tool (RFF 2025). The black line shows total global observed CO₂ emissions from the International Energy Agency (IEA). The solid green line is the emission trajectory developed by BP Energy taking account of current emission control policies and global energy use outlooks. It overlaps a solid black line which represents the emission projection from the IEA also taking account of energy use projections and current policies. The dashed lines show the range of IPCC SSP policies. As of 2023 global CO₂ emissions have been tracking well below the SSP scenarios especially the two highest ones (SSP5-8.5 and SSP3-7.0).

Carbon dioxide emissions (Million metric tons), by Outlooks & Scenarios. Filtered by Region: World; Fuel: All; Outlook: 2023 Shell (Sky 2050).

Source: RFF Global Energy Outlook at www.rff.org/geo

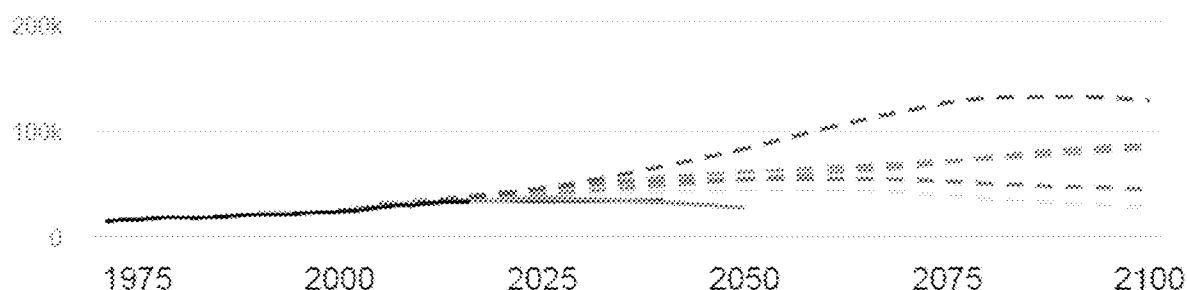


Figure 4.2.1. Observed and projected CO₂ emissions. Source: RFF (2025).

4.2.2 The carbon cycle relating emissions and concentrations

Global carbon cycle models relate concentrations to emissions using estimates of various land and ocean processes that remove CO₂ from, and emit CO₂ into, the atmosphere. Our understanding of these processes was reviewed by Crisp et al. (2021). The natural fluxes of CO₂ in and out of the Earth's surface are very large, many times anthropogenic emissions, but those CO₂ sources and sinks were assumed to be in approximate balance in pre-Industrial times, as evidenced by relatively constant levels of atmospheric CO₂ in centuries past derived from air bubbles in ice cores. This is one of several reasons why increasing atmospheric CO₂ levels are believed to be dominated by anthropogenic sources.

Specifically, fossil fuel burning (and to a lesser extent land use [biomass burning] and cement production) has led to steadily increasing CO₂ levels in the atmosphere, as shown in Fig. 1.2.1. CO₂ emissions from fossil fuel burning is a small fraction of the natural carbon cycle components. About 44,000 Gigatonnes of carbon-equivalent (GtC) are stored in the atmosphere and oceans, mostly in the form of CO₂. (Ciais et al. 2013). Between 150 and 200 GtC are released naturally each year through oceanic outgassing and land-based processes like plant decay and animal respiration. A variable but roughly equivalent amount is absorbed each year by the land and oceans, with a small net loss from the atmosphere because the formation of deep ocean sediment sequesters some carbon permanently. Global fossil fuel consumption and cement manufacture released about 10.3 GtC in 2023, up from 6.2 GtC in 1990 (Ritchie et al.

2024). Of this, about half is naturally sequestered through plant growth and oceanic uptake while the remainder, about half, adds to the atmospheric stock (Ciais et al. 2013).

As noted, each year natural processes remove a net amount of CO₂ equivalent to about 50% of global emissions. Thus, anthropogenic CO₂ emissions average twice what is required to explain the atmospheric rise in CO₂ concentration. The near-constancy of that 50% fraction (the “airborne fraction”) also means that the more CO₂ humanity produces, the faster Nature removes it from the atmosphere. That 50% fraction changes somewhat from year to year due to natural carbon cycle imbalances from El Nino, La Nina, and varying weather patterns. There was also a substantial additional reduction in atmospheric CO₂ after the 1991 eruption of Mt. Pinatubo, a curious result that has yet to be explained (Angert et al., 2004).

The main processes which remove excess CO₂ from the atmosphere are increased production of land vegetation (especially at high latitudes), some increase in the sequestering of carbon in soils, and uptake of CO₂ by the ocean due to the increasing partial pressure of atmospheric CO₂ over that of CO₂ dissolved in the ocean. All twenty land carbon cycle models tracked by the Global Carbon Project (Friedlingstein et al., 2024) show land processes have been removing excess CO₂ at an increasing rate since 1959. This is consistent with a “global greening” phenomenon observed by satellites since monitoring of global greenness began in the 1982. This greening has been traced to CO₂ fertilization and greater drought tolerance of plants exposed to elevated CO₂ levels. While there had been some uncertainty whether a greening trend continued beyond 2000, the most recent research (Chen et al., 2023) has shown continued greening, with even some slight acceleration since 2000. Global greening is discussed further in Section 3.1.

While land vegetation has been responding positively to more atmospheric CO₂, uptake of extra CO₂ by ocean biological processes remains too uncertain to be reliably measured. Our current understanding of these and many more carbon cycle processes was reviewed by Crisp et al. (2021).

Public policy can only change the rate of emissions, not the concentration in the atmosphere. For criteria air contaminants the rate and concentration are closely connected because the lifetime is short and the concentration is small. When emissions are reduced the local pollution concentration drops rapidly, usually on a time scale of a few days. Not so with the global average CO₂ concentration since global carbon cycle is vast and slow. A change in local emissions today will only have a very small global effect, and only after a long time lag. After a pulse (release) of CO₂ emissions to the atmosphere only about 40 percent ($\pm 15\%$) of the extra CO₂ will have been sequestered after twenty years. After a thousand years about 75 percent ($\pm 10\%$) will have been sequestered, and the remainder will gradually be removed over the ensuing tens of thousands of years (Ciais et al. 2013, pp. 472-473). Consequently US CO₂ emission reductions will take decades or centuries to lead to a reduction in the global CO₂ concentration.

To reduce the atmospheric stock of CO₂, assuming the entire increase is anthropogenic, would require emissions to fall below the natural sequestration rate. Since that rate has been averaging about 50% of emissions, a reduction of global emissions by 50% would (at least temporarily) halt the rise in atmospheric CO₂. The 1997 Kyoto Protocol proposed to cap industrial nations' CO₂ emissions at a modest five percent below 1990 levels by the year 2012. Even though this policy ended up too costly for most nations to implement, full compliance would not have substantially reduced atmospheric CO₂ levels. It would only have slightly slowed CO₂ growth, reaching the projected 2100 level in 2105 instead (Wigley 1998). Similarly, Lomborg (2016) used the widely-used MAGICC climate model and showed that full compliance with the Paris Accord would not stop warming, it would only prevent about 0.1C warming and delay hitting the baseline year 2100 temperature levels by about a decade.

Thus, in contrast with conventional air pollution control, local actions yield extremely small local effects, and only after a long time lag. The practice of referring to unilateral US reductions as “combatting climate change” or “taking action on climate” reflects a profound misunderstanding of the scale of the issue. The scale problem is compounded by recognizing that US motor vehicles account only for about 4 percent of global CO₂ emissions so even a fifty percent reduction in those emissions would have a vanishingly small effect on the global climate.

4.3 Aerosols and the uncertainties associated with them

Climate sensitivity to CO₂ (Equilibrium Climate Sensitivity or ECS) cannot be directly measured in part because it represents the net effect of (at least) two counteracting forces: warming from GHG's and cooling from aerosols. The observed warming can be made to be consistent with a wide range of pairs of these forces. In the following schematic, the warming represented by the red arrow could be due to the High GHG warming/strong aerosol cooling pair, or the Low GHG warming/weak aerosol cooling pair, or something in between.

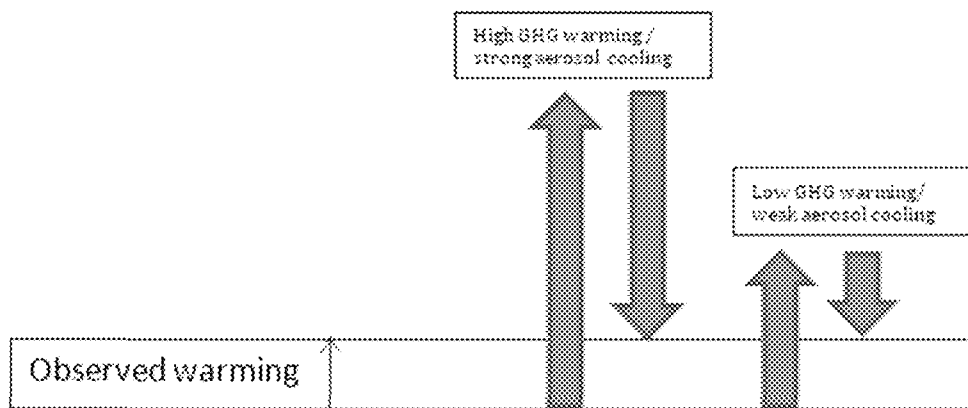


Figure 4.3.1: High and low climate sensitivity to GHGs can be reconciled with the same warming by assuming an offsetting aerosol cooling effect.

Consequently, research on the strength of aerosol cooling is central to forming valid ECS estimates. Lewis and Curry (2018) note that after the IPCC AR5 was published in 2013, eleven studies appeared in the scientific literature all finding that aerosol cooling was weaker than had previously been conjectured. Combining the updated aerosol estimates with greenhouse gas, ocean heat uptake and atmospheric warming data from the IPCC and applying standard empirical methods, Lewis and Curry (2018) estimated the best-guess ECS to be 1.66°C with a 95 percent uncertainty range of 1.15 °C – 2.7°C. They concluded that based on the ECS values derived from most IPCC climate models were incompatible with observed data.

Evidence of lower aerosol cooling (implying lower ECS) has continued to be found, such as Liu et al. (2021). Liu and his coauthors tested the hypothesis that aerosols from wildfires has increased since before the 20th century which, if true, would mean there had to have been relatively strong CO₂ warming over that period offsetting the aerosol cooling. They examined soot layers in ice cores extracted from Antarctica and South America and determined that wildfire activity prior to the 20th century was higher than previously believed. Instead of wildfire activity rising steadily from the 1700s to the present it was high all the way along, which means there was no increase in aerosols over that time—therefore the previously hypothesized aerosol cooling trend in the Southern Hemisphere over the 20th century did not happen. They pointed out how this finding relates to the climate sensitivity issue:

Accurate estimates of aerosol radiative forcing are also crucial for better understanding the transient climate response (TCR) and equilibrium climate sensitivity (ECS) to increasing CO₂ and more accurate projection of future climate change. The negative aerosol radiative forcing can, in part, cancel out the positive forcing of increasing

greenhouse gases and contribute to the uncertainty of total radiative forcing. An overly large aerosol cooling implies that models might overestimate TCR and ECS to reproduce historical temperature response. A recent study using one of the latest-generation CMIP6 climate models (E3SM) suggested that reducing both the magnitudes of negative aerosol radiative forcing and climate sensitivity yields a better agreement with the observed historical record of the surface temperature.

(Liu et al. 2021)

Liu told the UK Daily Mail¹

Climate scientists have known that the most recent generation of climate models have been over-estimating surface temperature sensitivity to greenhouse gasses, but we haven't known why or by how much. This research offers a possible explanation.

More evidence pointing to weak aerosol cooling was reported by Wang et al. (2021). They noted that the strength of aerosol cooling is partly mediated by cloud behavior and differs between the North and South Hemispheres because of the different density of aerosol emissions. This allowed them to construct another test of climate model validity, which came out in favor of low ECS models. In their words:

Since anthropogenic aerosols primarily concentrate in the Northern Hemisphere, strong aerosol-cloud interaction models produce an interhemispheric asymmetric warming. We show that the observed warming asymmetry during the mid to late 20th century is more consistent with low ECS (weak aerosol indirect effect) models.

Wang et al. (2021)

To summarize, measuring the effect of CO₂ warming requires making an assumption about the strength of aerosol cooling. While it is very uncertain a substantial body of recent evidence points to it being relatively weak, which implies CO₂ warming is likewise weak. The literature estimating ECS will be reviewed in Section XX.

¹ Available online at <https://www.dailymail.co.uk/sciencetech/article-9629919/Climate-change-warming-effect-greenhouse-gases-overestimated-ice-core-study-suggests.html>

Summary

- The global climate is naturally variable. Anthropogenic CO₂ emissions add to that variability by changing the total radiative balance in the atmosphere.
- The IPCC has downplayed the potential role of the sun in climate change but there are Total Solar Irradiance reconstructions that imply it may have played an important role, and the modern record is uncertain due to an interruption in satellite coverage.
- When anthropogenic emissions estimates along with carbon cycle model estimates of atmospheric CO₂ removal are combined we get estimates of future CO₂ concentrations and hence the radiative forcings required by climate models to estimate future rates of warming.
- IPCC emission scenario envelopes have tended to exceed observed trends.
- The vast majority of academic climate “impacts” studies in recent years are based on the RCP8.5 scenario that is considered implausible, and its usage as a business-as-usual scenario is misleading.
- Despite ample evidence that scenario envelopes are exaggerated, and despite criticism of this practice in the peer-reviewed literature, the IPCC’s most recent scenario set called SSP carries on with this pattern.
- The global carbon cycle heavily dampens the effect of changes in local (e.g. U.S.) CO₂ emissions. Even global-scale emission reductions will have only small effects, long in the future.
- Measuring the effect of CO₂ warming requires making an assumption about the strength of aerosol cooling. While it is very uncertain a substantial body of recent evidence points to it being relatively weak, which implies CO₂ warming is likewise weak.

Scaffeta, Nicola, Richard C. Willson, Jae N. Lee and Dong Wu (2019) Modeling Quiet Solar Luminosity Variability from TSI Satellite Measurements and Proxy Models during 1980–2018. *Remote Sensing* 11(21) 2569 <https://doi.org/10.3390/rs11212569>

Connolly, Roman, Willie Soon, Michael Connolly et al. (2021) How much has the Sun influenced Northern Hemisphere temperature trends? An ongoing debate *Research in Astronomy and Astrophysics* 21(6) doi: 10.1088/1674-4527/21/6/131 <https://iopscience.iop.org/article/10.1088/1674-4527/21/6/131>

Zacharias, Pia (2014) An Independent Review of Existing Total Solar Irradiance Records. *Surveys in Geophysics* 35 pp. 897—912 <https://link.springer.com/article/10.1007/s10712-014-9294-y>

Liu, Pengfei et al. (2021) “Improved estimates of preindustrial biomass burning reduce the magnitude of aerosol climate forcing in the Southern Hemisphere” *Science Advances* 7(22) May 2021 <https://doi.org/10.1126/sciadv.abc1379>

Wang, C., Soden, B. J., Yang, W., & Vecchi, G. A. (2021). Compensation between cloud feedback and aerosol-cloud interaction in CMIP6 models. *Geophysical Research Letters*, 48, e2020GL091024. <https://doi.org/10.1029/2020GL091024>

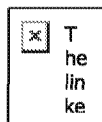
From: Judith Curry [curry.judith@gmail.com]
Sent: 6/16/2025 2:54:56 PM
To: Steven Koonin [steven.koonin@gmail.com]
CC: Ross McKittrick [ross.mckittrick@gmail.com]; John Christy [climateman60@gmail.com]; Roy W. Spencer [roywspencer@hotmail.com]; Travis Fisher [travis.scott.fisher@gmail.com]
Subject: Pielke's latest

Excellent stuff in Pielke's latest substack, seems a shame not to integrate some of this into Ch 11, 12 of CWG report

<https://rogerpielkejr.substack.com/p/the-most-amazing-climate-policy-figure>

.....

--



Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

From: Roy Spencer <roywspencer@hotmail.com>
Sent: Wednesday, May 7, 2025 12:40 PM
To: Travis Fisher; Judith Curry
Cc: Steven Koonin; John Christy; Ross McKittrick
Subject: Politico's article on those who have influenced Sec. Wright

For your entertainment and viewing pleasure, here's my blog response, which links to this morning's Politico article.

-Roy

<https://www.drroyspencer.com/2025/05/politicos-hit-piece-on-me-and-energy-secretary-wright/>

From: Travis Fisher <travis.scott.fisher@gmail.com>
Sent: Wednesday, May 7, 2025 10:37 AM
To: Judith Curry <curry.judith@gmail.com>
Cc: Roy Spencer <roywspencer@hotmail.com>; Steven Koonin <steven.koonin@gmail.com>; John Christy <climateman60@gmail.com>; Ross McKittrick <ross.mckittrick@gmail.com>
Subject: Re: Glossary

I'd be happy to take on the next version of the glossary. You don't need a PhD to do that, and I'm happy to take anything like that off your hands!

On Wed, May 7, 2025 at 10:31 AM Judith Curry <curry.judith@gmail.com> wrote:
thx for doing this. There are alot of acronyms used in the various chapters that should be included also

On Wed, May 7, 2025 at 3:45 AM Roy Spencer <roywspencer@hotmail.com> wrote:
Attached is my first cut at a glossary, 64 terms so far based upon my reading of the chapters.

I've omitted obvious things like EPA, CO2, NOAA, NASA...

I'm sure I missed a few terms, and feel free to make edits.

Of course, this could all wait until everything else is completed.

-Roy

From: Steven Koonin <steven.koonin@gmail.com>
Sent: Tuesday, May 6, 2025 9:02 PM
To: John Christy <climateman60@gmail.com>
Cc: Ross McKittrick <ross.mckittrick@gmail.com>; Judith Curry <curry.judith@gmail.com>; Roy W. Spencer <roywspencer@hotmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>
Subject: Re: Ch 8 Extreme weather

I was expecting to read/comment/edit Chapter 8 tomorrow (Wednesday), so I'll use this version. Roy, if you beat me to a summary, that's fine, else I'll take it on.

John, do decouple for at least a few days. I've made the mistake of not doing so on a few vacations, with great regrets afterward.

Steven Koonin

On May 6, 2025, at 21:53, John Christy <climateman60@gmail.com> wrote:

All

Here is a cleaned up version of chapter 8 which you will likely not see until 7 May, so that is the date.

My preference is for someone to read the thing and write the summary (8.4) based upon what a fresh set of eyes would conclude. Steve? Roy?

Ross. The panel charts of the individual station precipitation take up a lot of real estate and I think the value per acre is low. Since you calculated 3 statistics for each station, could you craft a bar chart or something to show that result? You would then have 9 charts, one for each of the 3 statistics and one each of the three regions. The nine charts may be panelized and fit on one plot. I know for us it's important for people to see the actual data (which is why I had those colored bar charts - now monochromatic), but it may be overkill for this document.

As to one of the statistics, I believe 3-day totals will be more meaningful and accurate than 1-day totals. I could send you a file of the heaviest 3-day total for each station and each year and you can do the analysis from there.

I especially like the way you parsed the Sidebar and I hope smart people will finally understand that when dealing with climate, our sample is pathetically small from which to draw hard conclusions.

I also enjoyed the added words on LTP. In fact do you have a few sentences that expand that a little to talk about the erratic nature of precipitation (spatial and temporal) in fancy statistical terms which means finding statistical significance in such a variable is a tough job?

I redid the number-of-event bar charts - all one color now.

I reran the Heatwave results to use 6-day periods as did NCA5. NCA5 was slick though. By choosing 1961-90 their background climatology was cold relative to decades before and since, so that results outside of those 30 years would produce a lot of days that exceed the percentile threshold. Then in the urban heatwave website, they started in 1960, assuring a result that more temps would exceed the threshold in post-1990 years.

That's all I've got.

Aloha

John C.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science

Alabama State Climatologist
The University of Alabama in Huntsville
climateman60@gmail.com

<8 Extreme weather.JRC.May07.docx>

On May 6, 2025, at 5:25 PM, John Christy <climateman60@gmail.com> wrote:

Steve

As Ross notes, the precipitation section is simply an update of our 2019 paper. The daily temperature work from the supplemented USHCN records is in a paper under review (but I suspect will have difficulty being accepted). The data are from the official USHCN site with my supplements adding about 10 percent to cover the missing data. There are about 41 million temperatures here, so I added about 4 million. Thus the results are dominated by publically-available data for others to check. If I get the go-ahead for publication, I can put the complete datafiles on a server for anyone to use.

John C.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
climateman60@gmail.com

On May 6, 2025, at 3:48 PM, Ross McKittrick
<ross.mckittrick@gmail.com> wrote:

The underlying analysis is all from John's and my Journal of Hydrology paper for which the code is already online. John updated and expanded the data sets and I ran them through the same code.

On Tue, May 6, 2025 at 4:41 PM Steven Koonin
<steven.koonin@gmail.com> wrote:

A thought about the analysis of long-term CONUS data, which as John knows I like very much:

If some (most?) of this work is as-yet unpublished in a peer-reviewed journal, I'd think you've got to make the expanded and in-filled database (and analysis code?) publicly accessible so that the work can be checked. Are you prepared to do that (at least for the "final", if not the "draft")?

SEK

From: Ross McKittrick <ross.mckittrick@gmail.com>
Sent: Tuesday, May 6, 2025 1:05 PM
To: John Christy <climateman60@gmail.com>
Cc: Judith Curry <curry.judith@gmail.com>; Roy W. Spencer <roywspencer@hotmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>; Steven Koonin <steven.koonin@googlemail.com>
Subject: Re: Ch 8 Extreme weather

Here's another edition of Ch 8 on extremes taking Judy's and John's points into account. The IPCC/NCA review is ported to an Appendix. I added a paragraph about LTP to the intro. I've incorporated the NE data. The bulk of the chapter is John's US temperature and precip data analysis with some additional material on wildfires, drought and TCs. For the US temperature extremes I moved the range figure to come just after the hot/cold extremes count because I think they both make a coherent point namely that the US becoming less extreme because heat events are rising more slowly than cold events are warming. There will still need to be an overall chapter summary but I'm going to move on to other chapters now. I'll put this in the Dropbox.

On Tue, May 6, 2025 at 12:12 PM John Christy <climateman60@gmail.com> wrote:

All

We can fill in without much trouble the change, or lack thereof, of "high impact" weather events (mainly wind and flooding like hurricanes, tornadoes etc) in the CONUS Extreme chapter. The temp and precip metrics are important because they are just long enough to essentially tell us Mother Nature has a mind of her own.

1. I'll look at Ross's version of 8 soon, but my hope was that Ross would translate the statistical remarks into the correct language(eg are their more precise words that chaotic, episodic, stochastic, etc).
2. We have analyses of the CONUS with more complete datasets than the NCA used (recall NCA analyses depended essentially on a small group at NCEI using datasets that (a)

were not very consistent in time, (b) could promote alarm and (c) already easy for them to get to. Our datasets have literally hundreds of thousands of manually keyed-in observations for temporal consistency. In other words, this lets people know we can address these issues from soup to nuts - we're not armchair climate scientists ... we can reproduce what they did, but make the analysis more comprehensive to address the questions.

John C.

Sent from my iPhone

On May 6, 2025, at 4:14 AM, Ross McKittrick

<ross.mckittrick@gmail.com> wrote:

Just read your attribution chapter. I hadn't picked up on the gap between IPCC Ch 11 vs Ch 12 language but i see your point that rather than promoting one set of attribution findings we should explain that even within the same AR different authors assessed things differently. One option is to leave Ch 6 where it is but reverse the order of Ch 7 and 8 while retitling the latter as you suggest. That way, having established the extreme weather types for which there are no detectable trends it will more naturally follow that they won't be discussed in the attribution chapter.

On Tue, May 6, 2025 at 9:45 AM Judith Curry
<curry.judith@gmail.com> wrote:

Ok, but the summary table (12.12 from AR6) is inconsistent with conclusions in AR6 ch 11 (I point this out in section 6.4 of my attribution chapter).

In my mind, the main point is disagreement and ambiguity I would suggest chapter 8 going before chapter 6, retitling it as US Weather and Climate Extremes, and make it more of a data chapter, not an attribution chapter (I would put table 12.12 in the attribution chapter if you want to include the actual table)

On Tue, May 6, 2025 at 6:39 AM Ross McKittrick <ross.mckittrick@gmail.com> wrote:

I like john's material too which is why I included it and am working on the extended regional analyses. But on this topic people are heavily primed to believe that extreme weather of all kinds is getting worse due to climate change. The assertion shows up everywhere climate change is discussed including in academic papers. I think it is very valuable to show people that neither the IPCC nor the NCA support such this view. We should at least lead off with the summary table. The library of quotes can go to an appendix but I have found in my public speaking that they have considerable persuasive force for most people. We also need to address floods, droughts, hurricane landfalls, tornadoes etc. I don't see any reason to delete all that material.

On Tue, May 6, 2025 at 9:22 AM Judith Curry <curry.judith@gmail.com> wrote:

I actually liked John's chapter. I would have retitled it "US temperature and rainfall extremes"

I think this is more relevant than a complete rehash of everything the last 3 IPCC reports have stated for every conceivable severe weather event.

John's version meshes very well with my version of chapter 6. Read especially section 6.4 of my chapter. I note a discrepancy between chapters 11 and 12 in terms of detecting and attributing extreme events. This is the main point in my opinion, there is ambiguity in all this. Lets focus on pointing out the problems/challenges, and topics that are particularly relevant for the US

On Mon, May 5, 2025 at 7:47 PM Ross McKittrick <ross.mckittrick@gmail.com> wrote:

I have wrangled the extreme weather chapter into something I hope flows better and is more readable. I adopted Judy's editorial changes and then the new changes I made are in red. I added some new Figures showing results on PC and SE data and will add the NE chart when I get the data. I also made some labeling suggestions including for the 3 rainfall charts that are hard to understand. Section summaries and an overall summary are still needed.
Ross

--

Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

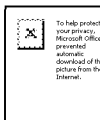
<~WRD0765.jpg>

--

Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

<~WRD0765.jpg>

--



Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

From: Steven Koonin <steven.koonin@gmail.com>
Sent: Tuesday, August 26, 2025 9:47 PM
To: Judith Curry
Cc: John Christy; Ross McKittrick; Roy Spencer
Subject: Re: Record US corn crop this year

A week from today, I believe.

Steven Koonin

On Aug 26, 2025, at 20:36, Judith Curry <curry.judith@gmail.com> wrote:

Well, i guess we will have comments to look at. anyone recall when the 30 days are up?

On Tue, Aug 26, 2025 at 3:38 PM John Christy <climateman60@gmail.com> wrote:
About the video chat ... bummer.

John C.

On Mon, Aug 25, 2025 at 1:58 PM Steven Koonin <steven.koonin@gmail.com> wrote:
https://www.wsj.com/finance/commodities-futures/huge-crops-in-corn-belt-hit-cash-strapped-farmers-with-more-unease-f9646641?st=gwm6Yi&reflink=desktopwebshare_permalink
Steven Koonin

--



Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

From: Judith Curry <curry.judith@gmail.com>
Sent: Tuesday, August 26, 2025 8:37 PM
To: John Christy
Cc: Steven Koonin; Ross McKittrick; Roy Spencer
Subject: Re: Record US corn crop this year

Well, i guess we will have comments to look at. anyone recall when the 30 days are up?

On Tue, Aug 26, 2025 at 3:38 PM John Christy <climateman60@gmail.com> wrote:
About the video chat ... bummer.

John C.

On Mon, Aug 25, 2025 at 1:58 PM Steven Koonin <steven.koonin@gmail.com> wrote:
https://www.wsj.com/finance/commodities-futures/huge-crops-in-corn-belt-hit-cash-strapped-farmers-with-more-unease-f9646641?st=gwm6Yi&reflink=desktopwebshare_permalink
Steven Koonin

--



Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

From: John Christy <climateman60@gmail.com>
Sent: Tuesday, August 26, 2025 6:38 PM
To: Steven Koonin
Cc: Judith Curry; Ross McKittrick; Roy Spencer
Subject: Re: Record US corn crop this year

About the video chat ... bummer.

John C.

On Mon, Aug 25, 2025 at 1:58 PM Steven Koonin <steven.koonin@gmail.com> wrote:
https://www.wsj.com/finance/commodities-futures/huge-crops-in-corn-belt-hit-cash-strapped-farmers-with-more-unease-f9646641?st=gwm6Yi&reflink=desktopwebshare_permalink
Steven Koonin

From: Steven Koonin <steven.koonin@gmail.com>
Sent: Monday, August 25, 2025 2:58 PM
To: Judith Curry; Ross McKittrick; John Christy; Roy Spencer
Subject: Record US corn crop this year

https://www.wsj.com/finance/commodities-futures/huge-crops-in-corn-belt-hit-cash-strapped-farmers-with-more-unease-f9646641?st=gwm6Yi&reflink=desktopwebshare_permalink

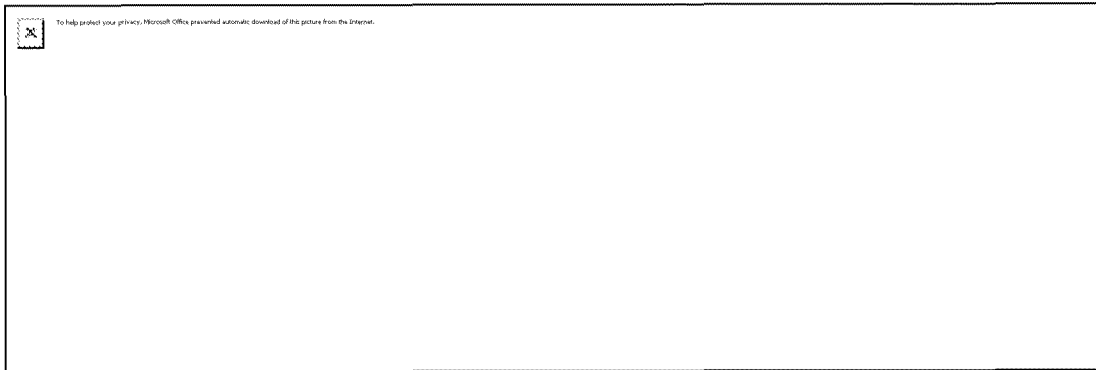
Steven Koonin

From: Ross McKittrick <ross.mckitrick@gmail.com>
Sent: Sunday, July 6, 2025 11:39 AM
To: Judith Curry; Roy W. Spencer; John Christy; Steven Koonin; Travis Fisher; Josh Loucks; Cohen, Seth
Subject: Fwd: Texas Flood Tragedy

----- Forwarded message -----

From: **Dr. Matthew Wielicki from "Irrational Fear"** <irrationalfear@substack.com>
Date: Sun, Jul 6, 2025 at 11:14 AM
Subject: Texas Flood Tragedy
To: <ross.mckitrick@gmail.com>

Forwarded this email? [Subscribe here](#) for more



Thank you for subscribing to the “Irrational Fear” substack by Dr. Matthew Wielicki.
Your support is greatly appreciated.

Texas Flood Tragedy

A Call for Truth and Action, Not Political Exploitation

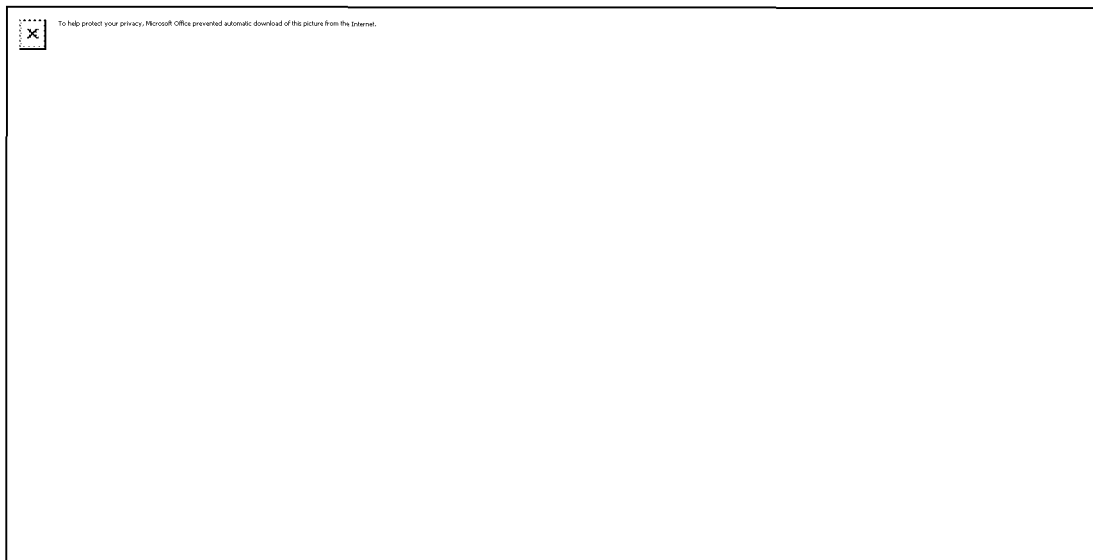
DR. MATTHEW WIELICKI
JUL 6



READ IN APP 

The heartbreaking flooding in central Texas, including the devastating loss of young lives at a girls' camp near Austin, is a tragedy that demands reflection, accountability, and action, not political grandstanding. This catastrophe, while

deeply painful, must be examined through a lens of historical and scientific clarity, not hijacked to push climate change or budgetary blame games.



<https://www.cnn.com/weather/live-news/texas-flooding-camp-mystic-07-06-25-hnk>

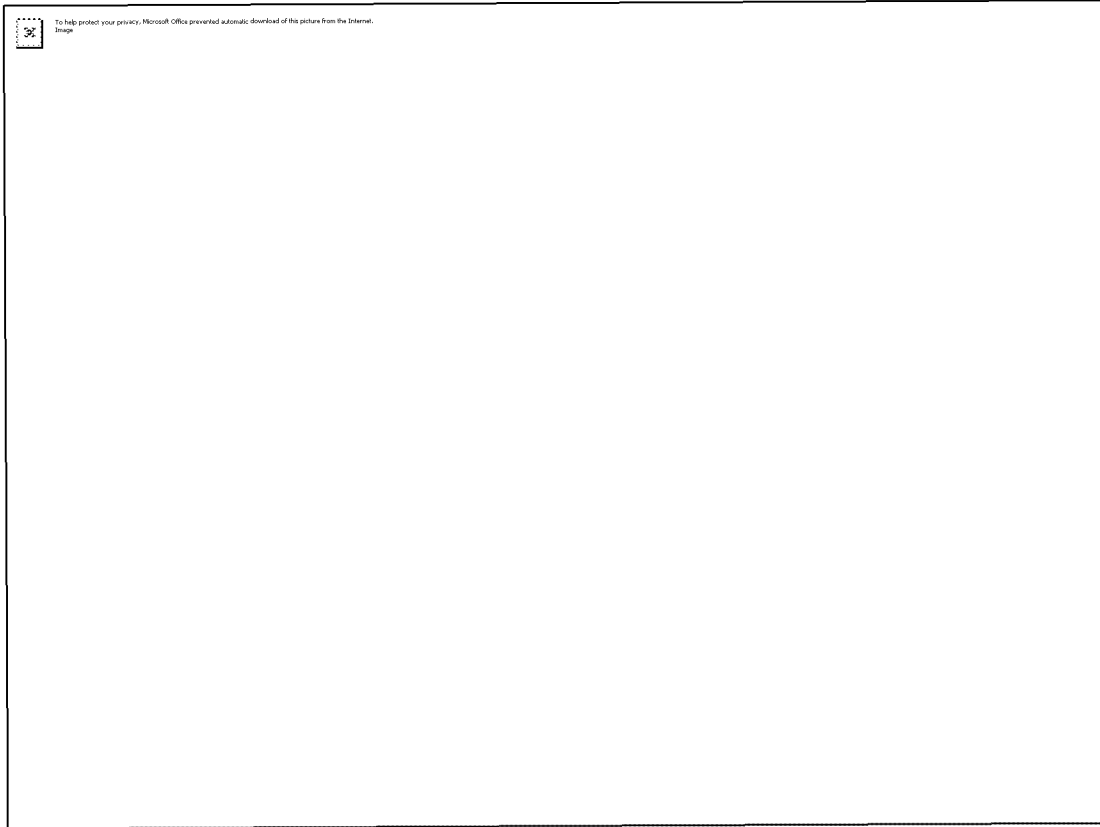
The Flooding Crisis: What Happened?

The severe flooding that struck central Texas, including areas near Austin, has brought renewed attention to the vulnerabilities of flood-prone valleys. Heavy rains rapidly overwhelmed local waterways, causing flash flooding that destroyed homes, infrastructure, and tragically claimed lives. Reports indicate that despite receiving advanced warning from weather services, the response at local and regional levels was tragically insufficient, highlighting critical gaps in emergency preparedness and land-use planning. I've previously detailed similar failures in emergency preparedness and the consequences in my article, *"Shifting the Blame"*.

Thanks for reading Irrational Fear! This post is public so feel free to share it.



Irrational Fear is a reader-supported publication. To receive new posts and support my work, consider becoming a free or paid subscriber.



Historical Context of Texas Flooding

Historically, central Texas is recognized as one of the most flood-prone areas in the United States. Flood events have occurred with devastating frequency and intensity for decades. The construction of dams and reservoirs throughout the 20th century was largely driven by the necessity of managing these frequent flooding episodes. Ironically, these infrastructure developments dramatically reduced flood magnitudes across many rivers, making the recent catastrophe even more indicative of infrastructure and regulatory failure than any long-term climatic shift. I expanded on the importance of historical context and its frequent omission from climate narratives in my earlier article, "*Unnatural Disasters*," dealing with the Palisades Fire, which was also blamed on climate change.

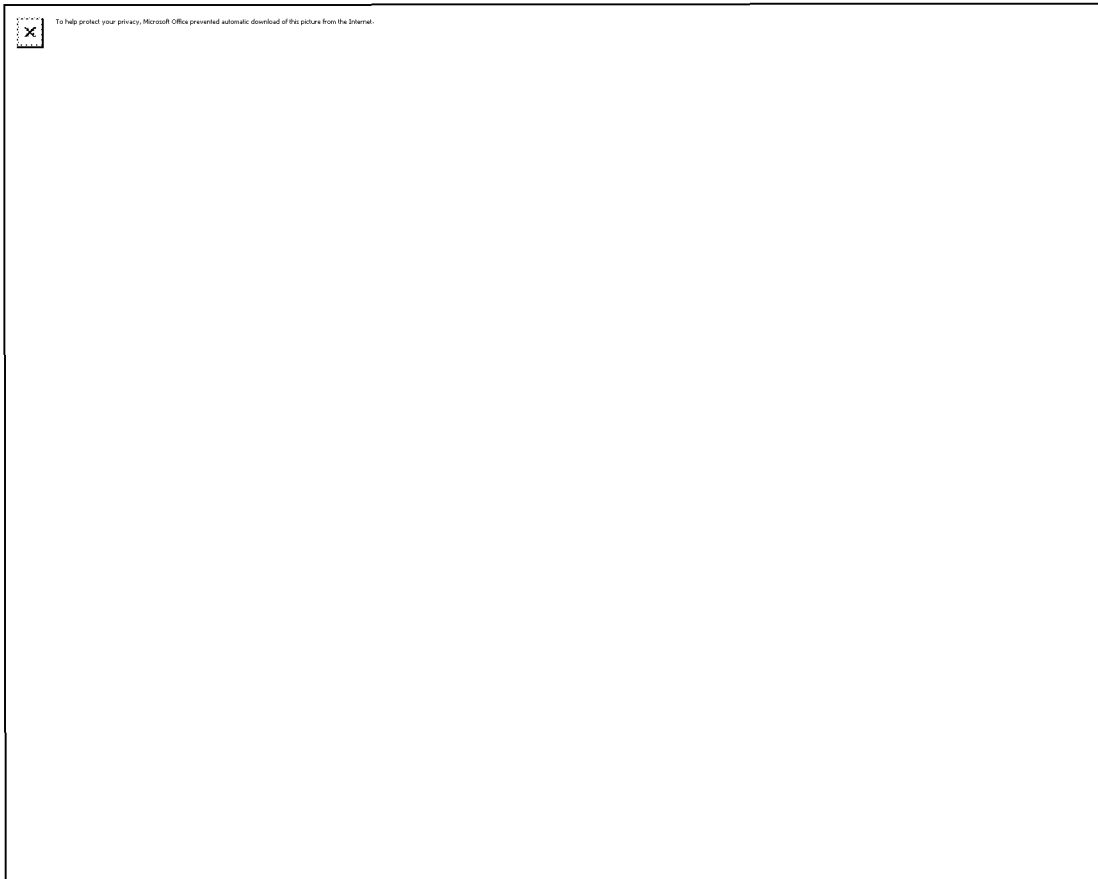
According to extensive research, including the recent Texas A&M 2024 Climate Report, river flooding in central Texas has not demonstrated a significant long-term increasing trend. The report explicitly states,

"No long-term river flooding trend has been identified in the observations, nor is such a trend projected at this point..."

Evaluating the Official Government Reports

Detailed examination of reports from the EPA and NOAA provides a critical counterpoint to simplistic climate narratives often pushed by the media and politicians. EPA documentation confirms that while the frequency of intense rainfall events has slightly risen, overall water availability and river flow in Texas have actually declined due to increased evaporation rates, changing vegetation, and altered land-use practices.

Additionally, NOAA and Texas A&M climate data explicitly contradict claims that extreme rainfall frequency and flooding are unprecedented or primarily climate-driven. Central Texas has experienced variable rainfall trends, with recent decades showing primarily decreasing precipitation, dependent largely upon specific locations within the state. EPA data plots show variability rather than clear upward trends in flooding events, undermining the narrative that climate change alone drives increased flooding... unless climate change is only working in certain parts of the country.

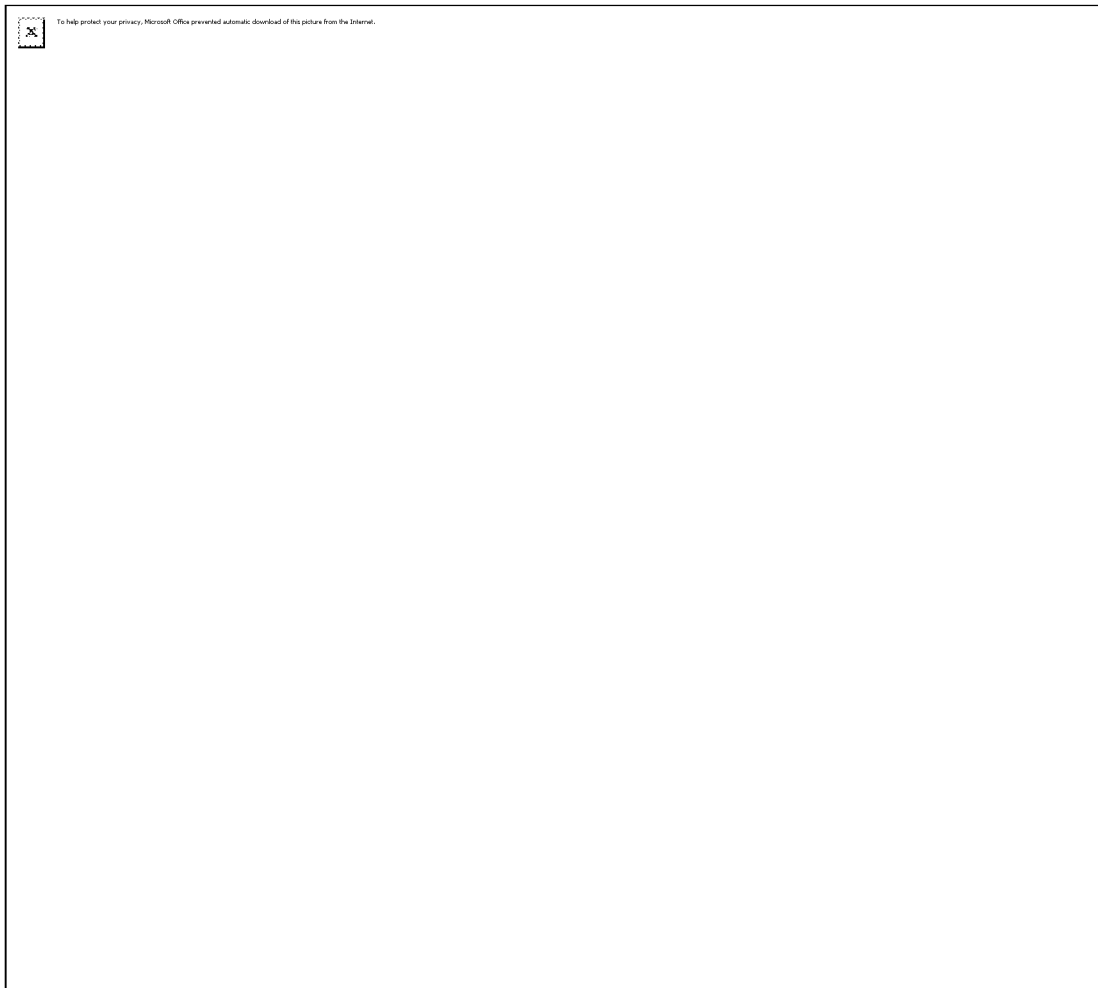


This figure shows changes in the size of flooding events in rivers and streams in the United States between 1965 and 2015. Blue upward-pointing symbols show locations where floods have become larger; brown downward-pointing symbols show locations where floods have become smaller. The larger, solid-color symbols represent stations where the change was statistically significant. Source: <https://www.epa.gov/climate-indicators/climate-change-indicators-river-flooding>

Dissecting the Climate Narrative and Political Exploitation

Despite clear data from authoritative sources, politicians and certain climate scientists quickly leveraged the tragedy to blame recent federal budget cuts to agencies like [NOAA](#) and the [National Weather Service](#). They suggested these budgetary adjustments significantly impaired weather forecasting, amplifying fatalities from severe weather events.

One particularly egregious example is a recent statement by Jay Inslee, who attempted to link President Trump's policy actions on renewable energy directly to the Texas floods, claiming cuts to solar and wind energy have exacerbated extreme weather.



This claim is not only scientifically baseless but profoundly insensitive, using tragedy to push a political agenda.

However, historical records of flood-related fatalities...



clearly shows no definitive upward trend correlating with agency budgets, GHG concentration, or global average temperature. Death tolls from flooding fluctuate year-to-year without demonstrable dependence on changes in agency staffing or funding. These data-driven insights expose the politically motivated nature of claims linking recent budgetary decisions to tragic fatalities.

The Reality of Warnings and Response

Importantly, media reports confirm that local authorities and residents had ample warning of the impending severe weather event, over 12 hours of advanced notice.

“According to the National Weather Service website, the flash flood watch, which included Kerr County, was issued at 1:18 p.m. Thursday. Nearly 12 hours later, a “life threatening” flash flood warning was issued at 1:14 a.m., according to the website.”

Despite this clear and timely warning, the emergency response and community preparedness failed catastrophically. The failure was one of planning, zoning, and infrastructure, not the availability or accuracy of weather data, nor GHG concentration.

Real Solutions, Not Climate Alarmism

The misdirection towards climate alarmism distracts from pragmatic, essential responses needed to safeguard lives and property. The tragedy at the girls' camp highlights dire deficiencies in land-use regulations and flood infrastructure. Building camps or residential areas within flood-prone valleys without adequate mitigation measures inevitably invites disaster.

Practical solutions exist: strengthening flood infrastructure, improving land-use zoning, investing in better emergency management systems, and implementing stricter regulations to restrict development in flood-prone areas. These solutions are immediate, actionable, and demonstrably effective, unlike vague climate-oriented rhetoric.

A Commitment to Continuous Data-Driven Updates

Moving forward, I commit to yearly updates analyzing new data on flooding events and fatalities, specifically to evaluate if the Trump administration's budget cuts directly contribute to increased flooding fatalities. When these updates definitively demonstrate that budgetary adjustments have not led to an increase in fatalities, it raises a critical question: Will those who perpetuate this misleading narrative be held accountable?

Subscribe today at [IrrationalFear.com](https://irrationalfear.com) to gain access to these critical yearly updates and nearly 400 detailed articles dedicated to dismantling climate misinformation. For the price of a single cup of coffee, equip yourself with the insights necessary to discern political narratives from scientific realities.

Thanks for reading Irrational Fear! This post is public so feel free to share it.



Irrational Fear is a reader-supported publication. To receive new posts and support my work, consider becoming a free or paid subscriber.



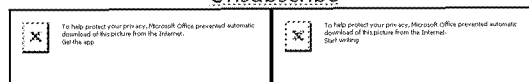
Thank you for your support. Irrational Fear is a reader-supported, independent publication. Please consider sharing Irrational Fear with your friends and family. Thank you, again!

Share Irrational Fear



© 2025 Dr. Matthew Wielicki

Unsubscribe



From: Judith Curry <curry.judith@gmail.com>
Sent: Friday, June 6, 2025 3:47 PM
To: John Christy
Cc: Ross McKittrick; Steven Koonin; Travis Fisher; Josh Loucks; Roy W. Spencer; seth.cohen@hq.doe.gov
Subject: sea level rise
Attachments: NCA SLR.docx

My text on sea level rise is attached. SK gave a preview of how crazy this is in his previous graph for The Battery. I have worked to simplify this and shorten, but it may need more.

ps recent files from my old laptop are non-recoverable, so I need to recreate hurricanes and 8.5 scenarios



Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

Global average sea levels over the past decade were also higher than in the preindustrial period by between 7 and 9.5 inches, with more than half of this rise occurring since 1980.

The issue with the NCA5 is not related to observed levels of sea level rise, but rather to their projections to 2050 and 2100. The NCA5 projections are inconsistent with the IPCC AR6 projections.

In the preamble Guide to Using This Report, the NCA5 shows a table on sea level rise projections, which is reproduced below.

Table 4. Descriptive Terms for Common Sea Level Rise Scenarios Used in NCA5

Future global mean sea level rise and sea level rise along United States coastline are shown for five scenarios in feet (and meters), relative to a 2000 baseline. The US values shown in the right half of the table are averaged across the US coastal regions, including the contiguous US, Alaska, Hawai'i and the US-Affiliated Pacific Islands, and the US Caribbean. The national values shown in the table differ substantially from regional values. For example, sea level rise is higher in the Gulf Coast and lower or even negative in some parts of Alaska. In the next 30 years (2020–2050), sea level along the contiguous US coasts is expected to rise 0.92 feet (0.28 m), the same amount of sea level rise observed over the last 100 years (1920–2020). See Chapter 9 for regional sea level information. Adapted from Sweet et al. 2022.⁹

Sea Level Rise Scenario Descriptor	Global Mean Sea Level			United States		
	2050	2100	2150	2050	2100	2150
Low	0.49 (0.15)	0.98 (0.3)	1.31 (0.4)	0.59 (0.18)	0.98 (0.3)	1.64 (0.5)
Intermediate-Low	0.66 (0.20)	1.64 (0.5)	2.62 (0.8)	0.75 (0.23)	1.64 (0.5)	2.95 (0.9)
Intermediate	0.92 (0.28)	3.28 (1.0)	6.23 (1.9)	0.89 (0.27)	3.28 (1.0)	6.89 (2.1)
Intermediate-High	1.21 (0.37)	4.92 (1.5)	8.86 (2.7)	1.12 (0.34)	4.92 (1.5)	8.86 (2.7)
High	1.41 (0.43)	6.56 (2.0)	12.14 (3.7)	1.38 (0.42)	6.56 (2.0)	12.46 (3.8)

The sea level rise scenarios in Table 4 relate to specified amounts of sea level rise by 2100, whereby Low relates to 0.3 m, Intermediate-Low relates to 0.5 m, Intermediate relates to 1.0 m, etc. They do not relate directly to the SSP emissions scenarios.

The IPCC AR6 provides the following assessment for sea level rise through 2050, against a baseline period of 1995–2014 (nominally 2005). Considering only projections incorporating ice-sheet processes in whose quantification there is at least medium confidence, the GMSL projections for 2050, across all emissions scenarios, fall between 0.1 and 0.4 m (5th–95th percentile range).

Considering only processes for which projections can be made with at least medium confidence, relative to the period 1995–2014 GMSL will rise by 2050 between 0.18 [0.15–0.23, likely range] m (SSP1-1.9) and 0.23 [0.20–0.30, likely range] m (SSP5-8.5), and by 2100 between 0.38 [0.28–0.55, likely range] m (SSP1-1.9) and 0.77 [0.63–1.02, likely range] m (SSP5-8.5).

Under a range of potential global warming levels, average sea level along US coastlines is likely to be between 12 and 20 inches above 2000 sea levels in 2050 (Figure 9.2)

Most tellingly, the projections to 2050 (baseline 2000) can be evaluated with respect to the observed global sea level rise from 2000-2024, which is approximately 10.2 cm (4 inches).

86 mm though Aug 2024 3.39 inches or 0.28 feet

<https://www.climate.gov/news-features/understanding-climate/climate-change-global-sea-level>

Under a range of potential global warming levels, average sea level along US coastlines is likely to be between 12 and 20 inches above 2000 levels in 2050 (Figure 9.2).

Chapter 9

Looking toward the future, an 11 inch 28 cm average rise along the contiguous US coastline is expected by 2050 (relative to 2020), with a likely range of 9-13 inches. See table A1.2 for 2000-2020 offsets, representing ongoing SLR acceleration that falls between the Intermediate-Low and Intermediate sea level scenarios

Beyond 2050, future global emissions and resultant ocean and atmospheric warming and ice sheet responses will determine future SLR. As of 2021, global temperatures have increased by 2-2.2F (1.1 -1.2C) beyond preindustrial levels and are headed for a warming level of about 5.4F (3C) by 2100 under the current trajectory, which is consistent with the IPCC AR6 intermediate and high scenarios (SSP2-4.5 and SSP3-7.0) With such warming, it is likely that the Intermediate-Low sea level scenario with 2+ft (0.6 m) of SLR relative to 2020 levels will be exceeded by 2100

Failing to curb future emissions increases the probability of SLR equivalent to

Chapter 2 states: Global average sea levels over the past decade were also higher than in the preindustrial period by between 7 and 9.5 inches, with more than half of this rise occurring since 1980. Assuming 1880 for the reference point for “preindustrial”, this sea level rise occurred over a period of 140 years.

IPCC AR6

As assessed in Section 9.4.2.2 and 9.4.2.3, there is therefore low confidence in simulating mechanisms that have the potential to cause widespread, sustained and very rapid ice loss from

Antarctica this century through MICI, and low confidence in projecting the driver of ice shelf disintegration.

In summary, detection of forced regional changes for some ocean areas in recent decades is possible (medium confidence), but attribution of regional sea-level change to forcings over longer periods (20th century) and for all ocean basins is not yet possible.

The simulated ocean dynamic and thermosteric response to external forcings during 1861-2005 is larger than simulated internal variability only in the Southern Ocean and North Pacific on a 1° grid (Slangen et al., 2015), but on spatial scales exceeding 2000 km a detectable signal is revealed in the last 45 years in 63% of the global ocean area (Richter et al., 2017). The thermosteric change in the upper 700 m in the period 1970-2005 shows similar observed and simulated forced geographical patterns, and anthropogenic forcing accounts for part (North Atlantic, 65%) or all (tropical Pacific, Southern Ocean) of the observed regional-mean (Marcos and Amores, 2014). The influences of greenhouse gases and anthropogenic aerosols can be partially distinguished by considering geographical or vertical ocean temperature variations (Slangen et al., 2015; Bilbao et al., 2019; Fasullo et al., 2020). Zonal-mean forced ocean dynamic sea-level change alone is not detectable but, using spatial correlation, the global geographical pattern during the altimeter period is detectable in sea-level trends (Fasullo and Nerem, 2018). This pattern may already or will soon be detectable in individual years, based on an analysis of CMIP5 climate model simulations (Bilbao et al., 2015).

Anthropogenic forcing, dominated by greenhouse gases, has strengthened the meridional sea-level gradient in the Southern Ocean since the 1960s (Slangen et al., 2015; Bilbao et al., 2019; Fasullo et al., 2020). New evidence finds that observed zonal-mean total sea-level trends during 1993 to 2018 in all basins are inconsistent with unforced variability alone and consistent with the modelled response to external forcing (Richter et al., 2020).

In sections 9.6.3.3 and 9.6.3.4, likely ranges of the new global-mean sea-level projections are presented, incorporating only processes in whose projections there is at least medium confidence, consistent with headline projections in the AR5 and the SROCC. As emphasized by the SROCC, there is a substantial likelihood that sea level rise will be outside the likely range. As described in Box 1.1, since the definition of 'likely' refers to at least 66% probability, there may be as much as a 34% probability that the processes in which there is at least medium confidence will generate outcomes outside the likely range. Furthermore, additional processes in which there is low confidence (Section 9.4.2.4; Box 9.4) may also contribute to sea-level change. The presentation of likely sea-level change (Tables 9.8-9.9 and in Figures 9.27, 9.29) is therefore accompanied by a low confidence range intended to reflect potential contributions from additional processes under high-emissions scenarios. The low confidence range incorporates ice-sheet projections based on both structured expert judgement (i.e., a formal, calibrated method of combining quantified expert assessments that incorporate all potential processes) and projections from an Antarctic ice sheet model that includes the Marine Ice Cliff Instability (a specific uncertain process not generally included in ice sheet models).

Accounting for this shift, the conclusion of the SROCC is that, with medium confidence, GMSL will rise between 0.40 m (0.26–0.56 m, likely range) (RCP 2.6) and 0.81 m (0.58–1.07 m, likely range) (RCP 8.5) by 2100 relative to 1995–2014.

The AR5 and the SROCC projections of GMSL for the 2007–2018 period have been shown to be consistent with observed trends in GMSL and regional weighted mean tide gauges (Wang et al., 2021)

Low confidence is ascribed to projections incorporating MICI because there is low confidence in the current 14 ability to quantify MICI (Section 9.4.2.4). Low confidence is also ascribed to projections based on SEJ,

because individual experts participating in the SEJ study may have incorporated processes in whose quantification there is low confidence, and the experts' reasoning has not been examined in detail. In general, the range of GMSL projections based upon ice-sheet models not incorporating MICI overlaps with but is lower than projections incorporating MICI or employing SEJ

There is high agreement across published GMSL projections for 2050 and there is little sensitivity to emissions scenario (Figure 9.25, left panel). Up to 2050, projections are broadly consistent with xtrapolation of the observed acceleration of GMSL rise (Sections 2.3.3.3, 9.6.1.1, 9.6.1.2). Considering

only projections incorporating ice-sheet processes in whose quantification there is at least medium confidence, the GMSL projections for 2050, across all emissions scenarios, fall between 0.1 and 0.4 m (5th— 25 95th percentile range). Projections incorporating MICI or SEJ do not extend this range under RCP 2.6 or RCP 26 4.5 and extend the upper part of the range to 0.6 m under RCP 8.5. On the basis of these studies, we therefore have high confidence that GMSL in 2050 will be between 0.1 and 0.4 m higher than in 1995 to 2014 under low and moderate emissions scenarios and between 0.1 and 0.6 m under high emissions scenarios.

Conversely, there is low agreement across published GMSL projections for 2100, particularly for higher emissions scenarios, as well as a higher degree of sensitivity to the choice of emissions scenario (Figure 9.25, right panel). Considering only projections representing processes in whose quantification there is at least medium confidence, the GMSL projections for 2100 fall between 0.2 and 1.0 m (5th—95th percentile range) under RCP 2.6 and RCP 4.5, and between 0.3 and 1.6 m under RCP 8.5. Considering also projections incorporating MICI or SEJ (low confidence), the projections for 2100 fall between 0.2 and 1.0 m (5th—95th percentile range) under RCP 2.6, 0.2 and 1.6 m under RCP 4.5, and 0.4 and 2.4 m under RCP 8.5. In summary, RCP-based projections published since the AR5 show high agreement for 2050, but exhibit broad ranges and low agreement for 2100, particularly under RCP 8.5.

From: John Christy <climateman60@gmail.com>
Sent: Wednesday, July 9, 2025 3:23 PM
To: Steven Koonin
Cc: Ross McKittrick; Judith Curry; Roy Spencer; Josh Loucks; Travis Fisher
Subject: Re: WSJ on event attribution

Do you think our CWG/NCA5 report will make people stop using that rainfall-increase map?

John C.

Sent from my iPhone

On Jul 9, 2025, at 1:24 PM, Steven Koonin <steven.koonin@gmail.com> wrote:

https://www.wsj.com/science/environment/flash-floods-extreme-rain-attribution-science-99dfd2be?st=eBaKaB&reflink=desktopwebshare_permalink

Steve Koonin

From: Steven Koonin <steven.koonin@gmail.com>
Sent: Wednesday, July 9, 2025 2:24 PM
To: 'Ross McKittrick'; 'Judith Curry'; 'John Christy'; 'Roy Spencer'; 'Josh Loucks'; 'Travis Fisher'
Subject: WSJ on event attribution

https://www.wsj.com/science/environment/flash-floods-extreme-rain-attribution-science-99dfd2be?st=eBaKaB&reflink=desktopwebshare_permalink

Steve Koonin

From: Ross McKittrick <ross.mckittrick@gmail.com>
Sent: Wednesday, May 21, 2025 9:06 AM
To: Roy W. Spencer; Judith Curry; John Christy; Steven Koonin
Subject: Today

We'll meet at 11 to go through Ch 12. Should only take 15 mins.
I've noted the changes made in various chapters since yesterday and we will review those quickly.

Then we can discuss the report title and what we call ourselves. I haven't had any guidance from Travis on legal implications associated with our group name but he's meeting with the department GC tomorrow so he'll bring it up.

DoE Team Doc Review
Wednesday, May 21 · 11:00am – 1:30pm
Time zone: America/Toronto
Google Meet joining info
Video call link: <https://meet.google.com/zen-dnbt-mpj>

Remaining matters:

The intro/preface

Author bios

Travis asked yesterday to check if our preference is still to publish the report prior to and separate from any EPA action, let's discuss.

Timing: CW leaves the DoE at 2 PM tomorrow and wants to have a draft to read on his flight to California. Travis and Josh have been assembling the chapters we completed into a report template. There will be time for tweaks and corrections up to about noon on Thursday.

From: Judith Curry <curry.judith@gmail.com>
Sent: Thursday, July 17, 2025 8:18 PM
To: Ross McKittrick
Cc: Roy W. Spencer; John Christy; Steven Koonin; Travis Fisher; Josh Loucks; Cohen, Seth
Subject: Re: NCA5 critique July 17 edition
Attachments: NCA5.Review.July17.[RM] JC.docx

Ross, good additions. My further comments (toning it down in a few spots)

On Thu, Jul 17, 2025 at 2:41 PM Ross McKittrick <ross.mckittrick@gmail.com> wrote:

In the attached I have accepted all the various edits collected to this point, many of which were small and grammatical. I have made some new changes marked in Track Changes, summarized as follows.

p. 3 ES: *Framing climate policy as a morality play*: I didn't know what this meant and it would be difficult to explain in a bullet point so I think it is better to merge it into the other bullets as I have attempted to do.

Section 1.1: *We did not have access to the Public Comments and responses*: Others have in the past so we're not sure we couldn't have gotten them if we tried. More to the point even if we had had access, the proof of the pudding is in the eating. The poor quality of the final report is sufficient evidence that the review process is deficient.

We find that the NCA5 should not be relied upon... I rewrote this paragraph. The report will be read in light of the TX floods. We can't lead with a claim that NCA5 is excessively alarmist—that will be spun as us having our heads in the sand. In the aftermath of the CA wildfires and TX floods one of my concerns is NCA5 calls everything everywhere a crisis, which is as unhelpful for planning purposes as ignoring all risks. The failure to provide focus and identify adaptive priorities is a key weakness in both NCA4 and 5. Somewhere in the US there is a small area where a thousand people sleep soundly at night oblivious to a looming weather-related catastrophe that, while rare, may happen tomorrow, and if it does there will be a lot of needless death and destruction. The NCA5 does not help us find where this place is on the map and take remedial steps to save lives, because it doesn't outline the full range of known weather risks and cries wolf everywhere about speculative future risks.

Discussion of Kirchmeier-Young and Zhang p. 9 – rewritten. I found their US-only results online which really sink the NCA5 text.

Discussion of extreme precipitation Sct 4.1 – I ported details to CWG25 and to a footnote. So there are no self-citations in the reference list but we do rely on a footnote.

Sea level rise p. 18: we compare the observed **global** change over 2000-2024 to the projected **US** rate over 2025-2050. Are they equivalent? Also the trend ratios don't look right. 2000-2025 observed = 3.4 inches. Projection is 12 – 20 inches. So smallest trend for next 25 years is $(12 - 3.4) / 3.4 = 2.5x$ the recent trend and largest is $(20-3.4)/3.4 = 4.9x$ the recent trend. 2020-20205 trend is $(11-3.4)/3.4 = 2.2x$ current trend. Text modified accordingly.

Section 7 intro paragraph. Clarifying what the problem is.

8.1: I fixed the Section citations.

p. 21 *Failure to acknowledge benefits*: but Ch 9 does admit to some benefits. Problem is in Chapters 2 & 3, as we state in our own Ch 2.

Sct. 8.3: I expanded critique of NCA4 to bring the ES.5 diagram back in.

New section 8.4 to review how NCA4 and NCA5 handled the known risks in the TX Hill Country. Note: NCA4 only mentions Guadalupe River 1x (with regard to dryness in the headwaters area); NCA5 0x.

For the next round of revisions, since Steve is out of pocket until next week, I suggest Judy go next then Roy then John then Steve.

--



Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

Critique of the Fifth National Climate Assessment

EXECUTIVE SUMMARY	3
1 INTRODUCTION	4
1.1 ABOUT THIS REPORT	4
1.2 ABOUT THE NATIONAL CLIMATE ASSESSMENTS	4
1.3 STANDARDS FOR ASSESSING NCA PRODUCTS	5
2 NCA5 OVERVIEW CHAPTER: ADVOCACY LANGUAGE AND UNSCIENTIFIC TONE	6
3 OVERCONFIDENCE WHEN STATING CONCLUSIONS	7
3.1 INFLATED CERTAINTY LEVELS	7
3.2 OVERSTATING FINDINGS IN UNDERLYING SOURCES	9
3.3 EXAMPLE: EMERGENT CONSTRAINTS	9
4 ARBITRARY AND AMBIGUOUS TREND ANALYSES	10
4.1 AVERAGE AND EXTREME PRECIPITATION	11
4.2 HEATWAVES	11
5 INADEQUATE TRACEABLE ACCOUNTS	14
6 OVEREMPHASIS ON EXTREME SCENARIOS	16
7 CONFLATION OF NATURAL AND ANTHROPOGENIC CLIMATE CHANGES	18
8 SUMMARY EVALUATION OF NCA5 AND RECOMMENDATIONS FOR NCA6	19
8.1 COMPLIANCE WITH USGCRP'S STATUTORY OBLIGATION	19
8.2 ADHERENCE TO THE TENETS OF GOLD STANDARD SCIENCE	20
8.3 SUITABILITY FOR INFORMING FEDERAL CLIMATE AND ENERGY POLICY	20
8.4 NCA5 AND THE 2025 TEXAS FLOODS	22
8.5 RECOMMENDATIONS FOR NCA6	24
9 REFERENCES	25
10 APPENDIX: CHARGE TO THE REVIEW	27
ABOUT THE AUTHORS	28

EXECUTIVE SUMMARY

This report critically evaluates the Fifth National Climate Assessment (NCA5), finding it an inadequate basis for climate and energy policies. A detailed review of the foundational chapters on climate science raises several key concerns:

Scientific Integrity

- An advocacy tone, particularly in the Overview chapter, that is inconsistent with scientific objectivity
- Endemic overconfidence when stating conclusions, including inflated certainty levels and overstatement of findings from underlying sources
- No mentions of dissent, disagreement or controversies
- Policy prescriptions that ignore costs and tradeoffs

Flawed methodology

- Minimal discussion of observational inadequacies
- Use of short time periods for trend analyses; lack of a consistent rationale for choosing time scales
- Attribution is implied, not dissected
- Overemphasis on extreme scenarios for future emissions and sea level rise
- Inadequate traceable accounts to support key conclusions

Inadequate Review Process

- A review by the National Academy of Sciences, Engineering, and Medicine (NASEM) failed to identify some fundamental flaws in NCA5
- The NCA5 authors failed to adopt some improvements recommended by NASEM

The report shows NCA5 to be a biased and incomplete picture of climate science that skews toward excessive climate risk. Consequently, NCA5 should not be used as basis for climate and energy policies.

1 INTRODUCTION

1.1 About this Report

This report responds to a request from the Office of Science and Technology Policy (OSTP) Director Michael Kratsios (reproduced in the Appendix) [MAY HAVE TO MODIFY THIS] that we assess the suitability of the Fifth National Climate Assessment (NCA5 2023) for informing climate and energy policies.

To conduct this assessment, we reviewed NCA5 itself, the National Academies of Science, Engineering and Medicine (NASEM) review of the Third Order NCA5 Draft, and the USGCRP responses to that review. We have drawn upon our long experience working on advisory reports, including for the NASEM, the Intergovernmental Panel on Climate Change (IPCC), and other organizations as writers, reviewers, and study leaders. We have reviewed recent scientific developments in a separate report to Energy Secretary Wright (Climate Working Group 2025) herein denoted “CWG25”.

We find that NCA5 should not be relied on for policy making as it portrays an incomplete and misleading picture of current climate variability and how climate-related risks are or are not changing over time. NCA5 was selective and incomplete in its survey of climate science. The overall effect of its biases and omissions is an unfocused and excessively dire picture of climate risk.

To support our finding, the following sections of this chapter provide some background on the National Climate Assessments and the standards by which we have assessed NCA5. Chapters 2 through 7 detail important ways in which NCA5 fails to meet those standards. Finally, Chapter 8 summarizes our evaluation of NCA5 and makes recommendations for NCA6.

1.2 About the National Climate Assessments

The U.S. Global Change Research Program (USGCRP) was established by Presidential Initiative in 1989 and mandated by Congress in the Global Change Research Act (GCRA) of 1990 to develop and coordinate “a comprehensive and integrated United States research program which will assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change.”

The National Climate Assessment (NCA) Reports evolved from the GCRA requirement to:

Prepare and submit to the President and the Congress an assessment which (1) integrates, evaluates, and interprets the findings of the Program and discusses the scientific uncertainties associated with such findings; (2) analyzes the effects of global change on the natural environment, agriculture, energy production and use, land and water resources, transportation, human health and welfare, human social systems, and biological diversity; and (3) analyzes current trends in global change, both human-induced and natural, and projects major trends for the subsequent 25 to 100 years.

The five NCA Reports to date have interpreted this mandate in different ways:

- NCA1 (2000) was a multidisciplinary effort to study and portray in regional detail the potential effects of human-induced global warming on the United States.

- NCA2 (2009) was a relatively short report that not only focused on the potential consequences of climate change but also sought to identify potential adaptation measures and identify the highest priorities for future research.
- NCA3 (2014) was an expanded effort that continued along the lines of NCA2, and was distinguished by a comprehensive review process, including a review by the National Academy of Sciences. NCA3 introduced a traceability analysis for each key finding, including a description of uncertainties.
- NCA4 (2017/2018) was a further expanded effort that was published in two volumes: I Climate Science Special Report (CSSR), and II Impacts, Risk, and Adaptation in the United States. This was the first NCA report to devote significant effort to assessing climate science.
- NCA5 (2023) returned to a single volume format, reducing discussion of climate science to a cursory two chapters, with continuing focus on regional and sectoral impacts of climate change. NCA5 expanded its remit to topics that are arguably outside the purview of the USGCRP, focusing on “Climate Action” and policy recommendations with a social justice emphasis.

These successive interpretations of the NCA are poorly aligned with the GCRA’s statutory requirements. Only NCA4 gives serious consideration to climate science, which receives the great majority of USGCRP funding, and even then NCA4 misrepresents some important points. Natural climate variability is essentially dismissed as unimportant in NCA4 and barely mentioned in NCA5 in most contexts, despite the mandate to include both human-caused and natural climate change. Most significantly, NCA5 has redirected the focus away from climate science and even the hazard elements of impacts, towards evaluation of societal vulnerabilities and advocacy for particular policy options, especially deployment of wind and solar power generation.

1.3 Standards for Assessing NCA Products

Beyond the statutory requirements stated above, another pertinent standard is President Trump’s executive order of May 23, 2025, Restoring Gold Standard Science. It enumerates some of the characteristics of good science, namely that it should be:

- i. reproducible;
- ii. transparent;
- iii. communicative of error and uncertainty;
- iv. collaborative and interdisciplinary;
- v. skeptical of its findings and assumptions;
- vi. structured for falsifiability of hypotheses;
- vii. subject to unbiased peer review;
- viii. accepting of negative results as positive outcomes; and
- ix. without conflicts of interest.

For an assessment of policy relevant science, it is also important to include statements about the strength of knowledge. The IPCC’s approach to assessing strength of knowledge is based on judgment of the available evidence and agreement among experts. But there are more sophisticated knowledge characterizations for risk management. Here are the elements according to Aven (2017):

- The degree to which the assumptions made are reasonable/realistic based on background knowledge

- The degree to which data/information exists and are reliable and relevant
- The degree to which there is disagreement among experts (including those from different environments or academic fields)
- The degree to which the phenomena involved are understood and accurate models exist
- The degree to which the knowledge has been thoroughly examined with respect to unknown knowns (issues that are known to matter but are ignored, such as, in this context, natural variability).

2 NCA5 OVERVIEW CHAPTER: ADVOCACY LANGUAGE AND UNSCIENTIFIC TONE

NCA5 Chapter 1, “Overview”, holds a prominent place in the Report since it summarizes the entire report and is the only section that many will read. Chapter 1 is marred by an activist tone, language that aggressively promotes mitigation policies, and motivated optimism. As such, this chapter adds an imprimatur of scientific authority to naïve and simplistic declarations of opinion about public policy. Here are some examples.

Chapter 1 opens with:

The more the planet warms, the greater the impacts. Without rapid and deep reductions in global greenhouse gas emissions from human activities, the risks of accelerating sea level rise, intensifying extreme weather, and other harmful climate impacts will continue to grow. Each additional increment of warming is expected to lead to more damage and greater economic losses compared to previous increments of warming, while the risk of catastrophic or unforeseen consequences also increases.

This statement presupposes that all warming is anthropogenic, that all warming is bad and causes economic damage, and that warming intensifies extreme weather. Such sweeping generalizations go well beyond what science has or can establish. The statement also refers to growing risks without reference to their magnitude – a small risk that increases might still be a small risk, and a large risk might be only incrementally worsened.

On the next page one finds:

Each additional increment of warming leads to greater risks [here it lists 7 key components of society including food security and the economy] ... Without deeper cuts in global net emissions, climate risks to the US will continue to grow... Action to limit future warming and reduce risks can have near-term benefits and opportunities: low-carbon energy jobs, Improved air quality, Health benefits, Economic benefits...”

The authors write as if climate policy does not involve trade-offs and all measures to reduce future warming will be effective and beneficial. Neither the vast body of scholarship on climate science and economics nor historical experience support such simplistic claims (CWG25). Not every additional increment of warming leads to economic harms; in fact, NCA5 Chapter 19 acknowledges that there will also be benefits. Nor is climate policy guaranteed to benefit the economy; it could impose net costs. Such misleading statements are a disservice to policymakers.

Pages 8 and 9 of the Overview promote renewable energy options by noting, correctly, that the levelized costs of wind/solar generation have fallen sharply since 2010, and so offers this rationale for pursuing deep emission reductions:

Recent growth in the capacities of wind, solar, and battery storage technologies is supported by rapidly falling costs of zero- and low-carbon energy technologies, which can support even deeper emissions reductions. For example, wind and solar energy costs dropped 70% and 90%, respectively, over the last decade, while 80% of new generation capacity in 2020 came from renewable sources.

Yet it has long been known that intermittent renewables generation must be supplemented by dispatchable generation to meet grid reliability standards, and that doing so (*e.g.*, through natural gas, fission, or storage) significantly increases the total cost of electricity. Further, there are yet unmet synchronization challenges in electrical grids with heavy penetration of wind and solar generation. NCA5 fails to acknowledge these facts. But more importantly, we see no reason for NCA5 to be discussing renewable energy technologies and economics in the context of its mandate.

Page 17 of the Overview introduces the discussion of risks from extreme weather events by saying “Harmful impacts from more frequent and severe extremes are increasing across the country.” This creates the impression that extreme weather events are worsening and that disaster losses are driven by trends in extreme weather. While the section goes on to acknowledge that some of the increase is due to increases in the exposure and value of assets at risk, it then invokes the NOAA Billion Dollar Dataset as evidence of extreme weather getting worse. Scientists have shown that this is an invalid metric (CWG25 Section 10.2) since it measures the growth of vulnerable infrastructure, not the frequency of extreme weather, and indeed NOAA has recently withdrawn the data product. Even though the dataset was still distributed by NOAA at the time of the NCA5, the report authors failed to assess it skeptically and see that it was unfit for the purpose of measuring climate trends.

Page 23 of the Overview states, in large font:

Climate changes are making it harder to maintain safe homes and healthy families; reliable public services; a sustainable economy; thriving ecosystems, cultures, and traditions; and strong communities.

This statement cannot be evaluated on scholarly grounds and so doesn’t belong in a scientific assessment report. Its prominent inclusion points not only to the willingness of NCA5 authors to promote alarm, but also the ineffectiveness of the review process in eliminating such statements.

3 OVERCONFIDENCE WHEN STATING CONCLUSIONS

3.1 Inflated certainty levels

Overconfidence in stating conclusions has been an endemic problem in NCA Reports. The authors frequently make sweeping generalizations without appropriate caveats or acknowledging uncertainties. The overconfidence begins with inflated language to describe certainty levels.

NCA5 uses specific terms to convey information about scientific confidence associated with important findings, observations and projections. The Front Matter of NCA5 states that

confidence in a finding is based on the type, amount, quality, strength, and consistency of evidence; the skill, range, and consistency of methods to detect, evaluate, attribute, and interpret climate trends; and the degree of agreement across scientific information sources.

Table 1 from the Front Matter provides calibrated language for confidence assessments:

Very high:	Strong evidence (established theory, multiple sources, well documented and accepted methods, etc.). High consensus
High:	Moderate evidence (several sources, some consistency, methods vary and/or documentation limited, etc.). Medium consensus
Medium:	Suggestive evidence (a few sources, limited consistency, methods emerging, etc.) Competing schools of thought.
Low:	Inconclusive evidence (limited sources, extrapolations, inconsistent findings, poor documentation and/or methods not tested, etc.). Disagreement or lack of opinions among experts.

This terminology is obviously inflated: *high confidence* with just moderate evidence and medium consensus; *medium confidence* with only suggestive evidence and competing schools of thought. This inflation in terminology leads to overconfidence in conclusions.

Even with this inflated terminology, NCA5 further inflates the confidence level of many of its conclusions to well beyond what the IPCC has concluded with more thorough justification, and by incorrectly applying its own standards. An example is the conclusion about anthropogenic influence on climate change, arguably one of the most important scientific statements of the report.

Key Message 3.1 Traceable Account states:

There is *very high confidence* that emissions of GHGs from human activities, fossil fuel use in particular, have unequivocally caused *all* global warming observed over the industrial era.

while the corresponding statements from IPCC AR5 and AR6 are

AR5: It is *extremely likely* that *more than half* of the observed increase in global average surface temperature from 1951 to 2010 was caused by the anthropogenic increase in greenhouse gas concentrations and other anthropogenic forcings together. (IPCC, 2013)

AR6: The *likely* range of total human-caused global surface temperature increase from 1850–1900 to 2010–2019 is 0.8°C to 1.3°C, with a best estimate of 1.07°C. It is *likely* that well-mixed GHGs contributed a warming of 1.0°C to 2.0°C, other human drivers (principally aerosols) contributed a cooling of 0.0°C to 0.8°C, natural drivers changed global surface temperature by –0.1°C to +0.1°C, and internal variability changed it by –0.2°C to +0.2°C. It is *very likely* that well-mixed GHGs were the main driver of tropospheric warming since 1979.

The IPCC AR5 and AR6 statements provide likelihood assessments but not a confidence level. While NCA5 claims with *very high confidence* that fossil fuels have unequivocally caused *all* global warming, AR5 refers to “*more than half* of the observed warming” and AR6 provides a more nuanced statement that relates to a *likely* range of warming contributed to by human drivers.

3.2 Overstating findings in underlying sources

Although we did not do a detailed audit of NCA5's use of source material, spot checks suggest a pattern of overstatement.

Chapter 2 page 11 reports on an increase in precipitation in some areas and attributes it to "climate change":

Many eastern regions of the country are getting wetter (Figure 2.4). Average annual precipitation from 2002-2021 was 5%-15% higher relative to the 1901-1960 average in the central and eastern US, a trend attributable to climate change.

NCA5 attributes the claim to Knutson and Zeng (2018). But Knutson and Zeng did not say these things nor did they analyze this particular period. For 1981-2010 they cautioned that observed changes are consistent with natural variability, and they did not claim attributable trends were observed over the United States.

As another example of overstating findings, NCA5's Chapter 2 page 18 states

There is robust evidence that human-caused warming has contributed to increases in the frequency and severity of the heaviest precipitation events across nearly 70% of the US.

This is apparently attributed to Diffenbaugh *et al.* (2018) and Kirchmeier-Young and Zhang (2020). Diffenbaugh *et al.* presented ratios of observed occurrences of extreme events to simulated occurrence rates in CMIP6 models run with only natural forcings. They report that for 79% of the U.S., extreme rainfall events are currently more frequent than in simulations, and the ratio of occurrences will rise under future warming simulations. This is not "robust" evidence of anthropogenic influence since it requires readers to assume that climate models accurately simulate regional precipitation patterns, something that the IPCC AR6 states is uncertain (AR6 WGI SPM Box SPM 1.2, SPM Section C.1.3).

Kirchmeier-Young and Zhang used three global climate models to analyze extreme 1- and 5-day events in North America. They noted large differences among the three models in their simulated precipitation changes. Attribution results for the U.S. are reported in their online Supplement (Figure S4). Across six experiments (three models and two rainfall metrics) anthropogenic influence was detected in only one case. Also both cited references began their historical observational records only in 1961. Here again this is not "robust" evidence. It is merely suggestive, particularly since other studies have found natural variability to be predominant.

3.3 Example: Emergent constraints

Some of the overconfidence expressed by NCA5 arises by omitting discussion of counterevidence in the peer reviewed literature, ignoring dissent and disagreement. An example is the topic of "emergent constraints". NCA5 Chapter 3 page 17 invokes this concept to support its claim that key uncertainties in climate model projections have been reduced:

An approach to reduce uncertainty in climate change projections has matured over the past decade. It is known as "emergent constraints." The term refers to strong statistical

relationships between highly uncertain future climate parameters and observable trends or variations in the current climate, along with a physical explanation of this relationship.

Emergent constraints appeared in the climate modeling literature as an attempt to tie climate model behavior to climate observations in hopes of generating insight into real-world equilibrium climate sensitivity (ECS). Climate models exhibit a wide range of ECS values. The idea of emergent constraints is to examine whether the models with shared sensitivity values also share a common representation of some climate process (usually related to clouds) that might influence ECS. Suppose, for example, that in low-ECS models the total cloud fraction in the tropics is strongly correlated with that in the southern midlatitudes, but in high-ECS models the correlation is weak. Then researchers could examine whether the observed correlation is strong or weak and draw a conclusion about which type of model, and therefore which ECS value, is more likely.

A problem in the emergent constraint literature is that there has been a proliferation of proposed correlations with little physical motivation. NCA5 alludes to this in the Traceable Accounts section (p. 3-40) but not in the main chapter text. As shown by Schlund *et al.* (2020), many emergent constraints patterned on CMIP5 models (Coupled Model Intercomparison Project Phase 5, used for the IPCC 5th Assessment Report) failed to work on CMIP6 models (used for the IPCC 6th Assessment Report). In other words, the correlations between ECS and cloud processes present in CMIP5 models were absent in CMIP6 models, indicating that they were likely spurious rather than clues to physical processes governing the climate system. As a result, emergent constraints estimated on CMIP5 models *increased* the uncertainty of ECS, rather than decreasing it as claimed by NCA5.

Yet NCA5 described the use of emergent constraint analysis as an advance that reduced the uncertainty of ECS and climate model projections (p. 3-38):

Emergent constraints have been widely applied to reduce the simulated spread in the climate feedbacks that shape climate sensitivity.

4 ARBITRARY AND AMBIGUOUS TREND ANALYSES

CWG25 Chapter 6 discussed the need for care in the choice of time scale when making claims about trends in extreme weather. We provided examples from analysis of river flooding, heatwaves, and extreme precipitation to show how assertions about apparent trends based on short data sets fall apart when considering longer versions of the same data sets. NCA5 uses varying time periods for trend analyses, especially in Chapter 2 (which is focused on trends), without explaining why shorter or longer intervals were chosen. For example, page 2-4 defines temperature trends over the interval since the late 1800s whereas page 3-29 presents temperature trends over 1972-2021. Page 2-11 compares rainfall over the 2002-21 versus 1901-1960 intervals, while page 2-18 uses the interval since the late 1950s to compute trends.

A further problem is that NCA5 uses the term “trend” repeatedly without indicating if it is statistically significant (*i.e.*, distinguishable from random variability); the ambiguity creates the impression all the observed changes were significant, but readers are left to speculate. All climate variables will, in principle, drift up or down over any particular time interval. Identifying the change as a trend requires showing that it is statistically significant using a variance estimator suitable for the type of data being analysed. Of particular importance is choosing a method robust to the serial correlation that is frequently present in climate data. Throughout Chapters 1 to 3, references are made to

“trends” without explaining how they were computed. The exception was on page 1-19 which refers to urban temperature trends being calculated using the Theil-Sen estimator, although that method does not seem to have been used elsewhere. The one case where reference is made to statistical significance is on Page 2-9, referring to a trend in Atmospheric Optical Depth, but there is no explanation of how significance was determined. Page 2-19 refers to regional trends in droughts being “robust” but again fails to explain how the term was defined.

4.1 Average and Extreme Precipitation

NCA5 did not continue the NCA4 precedent of using the post-1901 interval as the time scale for its precipitation discussion. Instead, it refers to changes “since the 1950s”; NCA5 Figure 2.8 suggests 1958 might be the intended start date. Under Key Message 2.2, “Extreme Events Are Becoming More Frequent and Severe”, NCA5 states (p. 2-18):

Rainfall is becoming more extreme
Since the 1950s, there has been an upward trend in heavy precipitation across the contiguous US. This increase is driven largely by more frequent precipitation extremes, with relatively smaller changes in their intensity.

In addition to our concerns that inferences about trends are contingent on choice of time scale, if the intended meaning of this statement is that positive and significant trends are found in heavy precipitation events across CONUS, we cannot reproduce it. In CWG25 Section 6.4, in addition to referencing previous analyses in the climate literature we presented analyses of daily U.S. precipitation data for the Pacific Coast, Southeast and Northeast regions, in all cases finding both considerable regional heterogeneity and that trends in various measures of extreme precipitation detectable on one time scale are often not detected on longer or shorter time scales. Additional analysis of stations in the upper Midwest confirm this pattern.¹ Moreover the NCA5 statement was at odds with evidence in the peer-reviewed literature (discussed in CWG Section 6.4) to which authors of this report drew NCA5 authors’ attention during the review process.

The following is a more accurate summary of what U.S. precipitation data show.

There are regionally heterogeneous changes in average and extreme precipitation. Positive trends in annual average rainfall and extreme events (defined either as the annual maximum or the number of exceedances of the 99th percentile value) are generally weak or non-existent when looking at samples exceeding 130 years in length. Significant trends can be found when beginning the sample in the 1950s although in most cases the trends weaken and become insignificant when looking at the post-1980 interval. This argues against attribution of changes in precipitation to anthropogenic warming.

4.2 Heatwaves

In contrast to NCA5, NCA4 examined heat extremes across the entire 20th century, pointing out that peak heat wave activity was reached in the 1930s and has decreased since then, and that recent increases are confined to areas west of the Rockies. NCA4 stated:

¹ See details at https://www.nsstc.uah.edu/data/ushcn_jrc/SI.Precipt_trends_reproducing.pdf, which provides access to data and code.

[The] warmest daily temperature of the year increased in some parts of the West over the past century, but there were decreases in almost all locations east of the Rocky Mountains. In fact, all eastern regions experienced a net decrease, most notably the Midwest (about 2.2°F [1.2°C]) and the Southeast (roughly 1.5°F [0.8°C]).

Since the mid-1960s, there has been only a very slight increase in the warmest daily temperature of the year (amidst large interannual variability). Heat waves (6-day periods with a maximum temperature above the 90th percentile for 1961–1990) increased in frequency until the mid-1930s, became considerably less common through the mid-1960s, and increased in frequency again thereafter. As with warm daily temperatures, heat wave magnitude reached a maximum in the 1930s. (NCA4 pp. 190-191)

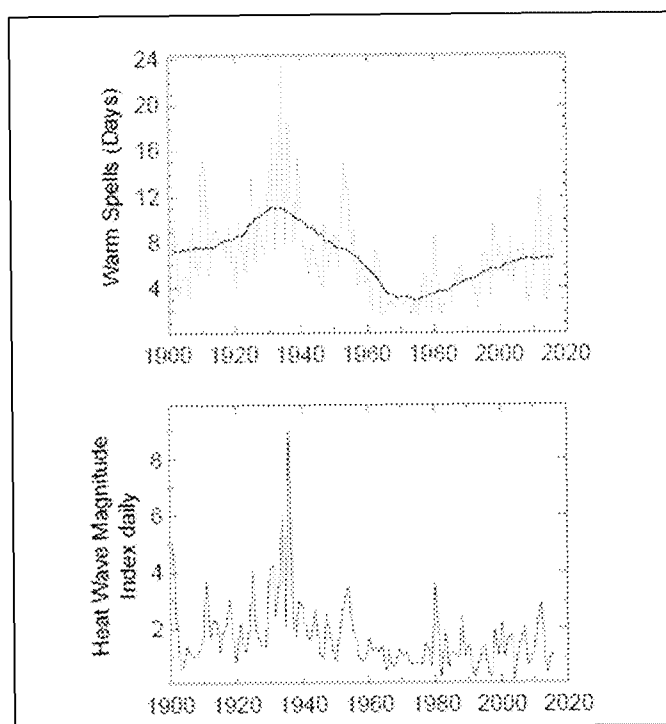


FIGURE 3. U.S. Heat waves since 1900. Reproduction of NCA4 Figure 6.4

Contrast this careful and factual language from NCA4 with NCA5 Key Message 2.2: “Extreme Events Are Becoming More Frequent and Severe.” This blanket statement is followed by NCA5 Figure 2.7 (reproduced as Figure 4 below) which shows the number of hot days, cold days and warm nights (respectively in panels a—c) over the period 2002-2021 compared to 1901-1960. Presumably these are annual counts, although this is not stated in the caption.

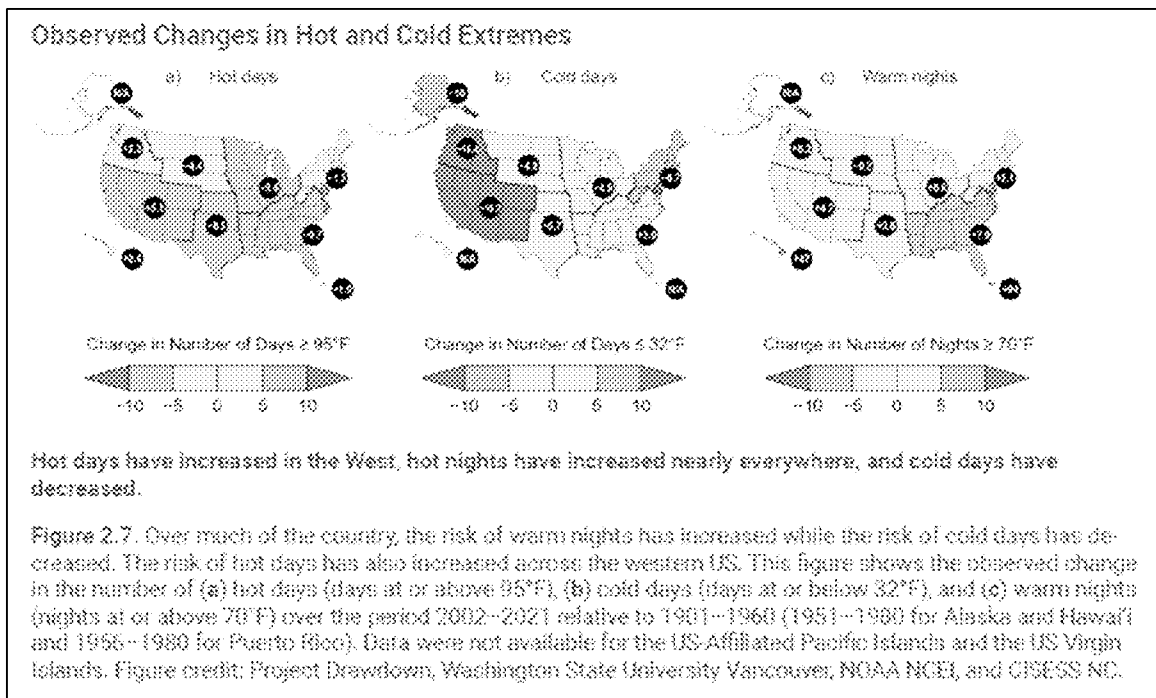


FIGURE 4: Reproduction of NCA5 Figure 2.7.

Close inspection shows that this figure actually contradicts the NCA5 Key Message with respect to heatwaves and instead reinforces the position of NCA4. Notwithstanding Key Message 2.2, the leftmost panel in NCA5 Figure 2.7 above shows that over most of CONUS the number of extreme heat days has *decreased* in recent decades compared to the prior century.

The accompanying discussion in NCA5 becomes convoluted as it appears to be aimed at supporting the Key Message despite the contrary evidence. NCA5 Chapter 2 elaborates on Key Message 2.2 by stating (page 2-16):

Observations show an increase in the severity, extent, and/or frequency of multiple types of extreme events. Heatwaves have become more common and severe in the West since the 1980s (*high confidence*).

But while it mentions the increase in hot days in the West, it fails to mention the decrease everywhere east of the Rockies. On the next page (page 2-17) it raises the comparison to the 1930s and then switches to discussing global counts:

By some measures, the most extreme heatwaves on record in the United States occurred during the Dust Bowl era of the 1930s. ... Globally such heatwaves are becoming more frequent, and in recent decades the western United States has been following those trends.

The reference to a global trend seems to be an attempt to tie heatwaves to anthropogenic climate change. But the obvious question, unaddressed by NCA5, is why one region follows the global pattern of increasing heatwaves while most of the country is trending in the opposite direction. These issues are addressed in Chapter 6 of CWG25, demonstrating that the range and magnitude of extreme temperatures are driven more by natural variability than by anthropogenic forcing. The analysis in CWG25 shows that for both (a) hot days ($\geq 95^{\circ}\text{F}$) and (b) number of days in heatwaves, the current decade is no hotter than a century ago in the U.S. Thus, the NCA5 claim that “multiday heatwaves

have become hotter, more frequent, larger, and longer lasting in recent decades,” is simply false when expanding the temporal and spatial domains to encompass all available data (Chapter 6 and Figure 6.3.6 of CWG25).

NCA5 then pointed to the dramatic Pacific Northwest heatwave of 2021. CWG25 Section 8.6.1 discusses this event in detail, reviewing the multiple peer reviewed studies that explained the unusual meteorological context was unrelated to human-caused climate change, a point omitted from the NCA5 discussion.

NCA5 finally addresses the declining heatwave trend in CONUS east of the Rockies but attempts to reframe it by focusing on urban warm spells.

[The] number of very hot days has actually decreased across the central and eastern regions due to summer cooling trends in the region (Figure 2.7; Ch. 22). This does not, however, mean the central and eastern US are not affected by heat. The impacts of extreme high temperatures are more severe if such conditions persist for several days, and overall, multiday heatwaves have become hotter, more frequent, larger, and longer lasting in recent decades. Across 50 large US cities, the US Global Change Research Program heatwave indicator (<https://www.globalchange.gov/indicators/heat-waves>) shows that the average number of heatwaves has doubled since the 1980s, and the length of the heatwave season has increased from about 40 days to about 70 days.

We discussed this part of NCA5 in CWG25 Section 6.3. The figure referenced by NCA5 uses a short time period which begins in the 1960s, the coldest decade in the last 100 years, thus suppressing any comparison to the 1930s. Further, nighttime temperatures in urban areas have increased faster than daytime temperatures (which NCA5 acknowledges), but this is a signature of urban heat islands and not a good metric of climate change. CWG25 found that the occurrence of hot days ($\geq 95^{\circ}$ F) has recently increased in the West but declined since 1899 in the remainder of the country and in the nationwide average.

5 INADEQUATE TRACEABLE ACCOUNTS

NCA3 began the practice of including a section on Traceable Accounts at the end of each chapter. This is the description from NCA5:

Each chapter concludes with a section entitled Traceable Accounts, which provides information on the overall process used to develop the chapter as well as a separate Traceable Account section for each Key Message. These Traceable Accounts describe the supporting evidence behind each Key Message, the process and rationale authors used in reaching their conclusions, and the author team’s expert assessment of the confidence in and, where applicable, likelihood of these conclusions. As such, Traceable Accounts provide information about the state of the science, document sources of uncertainty, identify research gaps, and allow traceability to data and resources.

The Traceable Accounts for each Key Message includes the following sections:

- Description of Evidence Base
- Major Uncertainties and Research Gaps

- Description of Confidence and Likelihood

The Traceable Accounts could have addressed the statutory requirement that the NCA discuss scientific uncertainties. They could also help satisfy the Executive Order for Restoring Gold Standard Science by addressing reproducibility, transparency, communication of error and uncertainty, and skepticism of findings and assumptions. However, the Traceable Accounts in NCA5's Chapters 2 and 3 are uneven, often superficial and uninformative.

An example of a deficient Traceable Account is NCA5's Key Message 2.2: "Extreme Events are Becoming More Frequent and Severe". The "Description of the Evidence Base" offers two paragraphs, the first summarizing the findings and the second generically describing the types of data that can be used for storms. "Major Uncertainties and Research Gaps" focuses on the uneven distribution across U.S. populations due to differences in exposure and vulnerability. The only limitations in data referred to are the lack of a long-term record of lightning and the lack of homogenized daily and hourly temperature data apart from reanalysis products.

But the most astonishing deficiency is in the "Description of Confidence and Likelihood." One of the statements in Key Message 2.2 is:

Hurricanes have been intensifying more rapidly since the 1980s (*high confidence*) and causing heavier rainfall and higher storm surges (*high confidence*).

The Description of Confidence and Likelihood includes the following statement:

Basic physical understanding and climate models both provide robust explanations for the links between climate change and observed changes in these extremes: this is why the authors also have high confidence that storms are delivering more rainfall and high confidence that storm surges are becoming higher.

No reference to journal publications or a specific data set is made anywhere in the chapter regarding hurricane-induced precipitation or storm surge to support this *high confidence* conclusion.

The Traceable Accounts for the various Key Findings of Chapter 3 have some substantial inconsistencies. Consider

Key Message 3-1: Human activities have caused global warming.

Confidence and Likelihood: "There is *very high confidence* that emissions of GHGs from human activities, fossil fuel use in particular, have *unequivocally* caused all global warming observed over the industrial era. There is also *very high confidence* that changes in natural climate drivers have had globally small and regionally variable long-term effects over this period."

The Uncertainties section addresses only uncertainties in radiative forcing by greenhouse gases, ignoring the great uncertainty in model responses to that forcing (CWG25 Chapters 4 and 5) In contrast, the Traceability Analysis of Key Message 3-4 ("Humans Are Changing Earth System Processes") raises the problem that relatively little is known about the role of natural variability at the regional scale. From its Description of Evidence Base:

In the last decade, there has been increasing recognition of the role of regional-scale natural variability in the past and future evolution of climate, as well as the fact that regional natural variability signals can be competitive with forced anthropogenic signals.

And from its Major Uncertainties and Research Gaps:

For example, the true natural variability of the climate system on decadal to centennial timescales could be larger than what we estimate from GCMs, which would further increase the irreducible uncertainty stemming from natural variability.

These statements are among the most scientifically credible in the entire NCA5 and they directly undercut the confidence assigned to Key Message 3-1.

There is also a generic problem in tracing NCA5's Traceable Accounts. The Front Matter of NCA5 states:

Each figure and some tables are accompanied by a metadata survey, which can be accessed in the online version of the report by clicking on the eyeball icon above the figure or table (see the table below for explanations of additional icons used throughout the report). The metadata survey describes data sources, figure or table development methods, copyright information, and other important documentation.

Clicking on the 'eyeball' icon does not reveal the metadata information; instead a "Contact Us" email appears, addressed to the USGCRP. This is an inadequate way to archive the metadata information.

In summary, the Traceable Analyses examined here, with few exceptions, fail to meet the stated objectives of the NCA.

6 OVEREMPHASIS ON EXTREME SCENARIOS

To respond to the GCRA mandate to "project major trends for the subsequent 25 to 100 years," NCA5 relies on projections of future climate change based on estimates of future emissions (the so-called SSP scenarios) and/or specified levels of radiative forcing (the RCP scenarios). For the most part, NCA5 uses scenarios developed for the IPCC Assessment Reports.

CWG25 Section 3.2.1 presented a critical assessment of past and current IPCC scenario envelopes, showing that they have tended to overshoot observed emissions. IPCC AR6 published in 2021 stated that "The likelihood of high-emission scenarios like RCP8.5 and SSP5-8.5 is considered low in light of recent energy sector developments." and that same year UN Climate Negotiators (COP) stopped using scenarios above 4.5.

NCA5 makes the following observations about the scenarios they use:

NCA5 authors were advised to assess the full range of scenarios available. (Front Matter)

Scenarios of future emissions and land-use change are developed as plausible alternatives, but no relative likelihood is attached to them. Some recent studies, however, have argued that

the highest scenario, SSP5-8.5, is no longer plausible without a reversal of current trends in the adoption of renewables and energy efficiency. (Key Message 3.3 Traceable Analysis)

Despite acknowledging the issue, NCA5 otherwise ignored the problem. A keyword search of NCA5 of mentions of RCP/SSP scenarios finds over 50% referred to the extreme emissions scenarios RCP8.5/SSP5-8.5. Further, nine NCA5 figures (5.2, 6.9, 7.4, 11.3, 14.6, 22.13, 22.19, 27.9, 29.13) included *only* the 8.5 scenarios.

The problem of relying on extreme scenarios is particularly acute for NCA5's sea level rise projections. The sea level rise scenarios used in NCA5 do not relate directly to the SSP emissions scenarios, but rather to specified amounts of sea level rise by 2100. Table 4 of NCA5's "Guide to Using this Report" reproduced below shows that Low relates to 0.3 m (0.98 feet), Intermediate-Low relates to 0.5 m (1.64 feet), Intermediate relates to 1.0 m (3.28 feet), Intermediate-High relates to 1.5 m (4.92 feet), and High relates to 2.0 m (6.56 feet).

Table 4. Descriptive Terms for Common Sea Level Rise Scenarios Used in NCA5						
Future global mean sea level rise and sea level rise along United States coastline are shown for five scenarios in feet (and meters), relative to a 2000 baseline. The US values shown in the right half of the table are averaged across the US coastal regions, including the contiguous US, Alaska, Hawaii and the US-Affiliated Pacific Islands, and the US Caribbean. The national values shown in the table differ substantially from regional values. For example, sea level rise is higher in the Gulf Coast and lower or even negative in some parts of Alaska. In the next 30 years (2020-2050), sea level along the contiguous US coasts is expected to rise 0.92 feet (0.28 m), the same amount of sea level rise observed over the last 100 years (1920-2020). See Chapter 9 for regional sea level information. Adapted from Sweet et al. 2022."						
Sea Level Rise Scenario Descriptor	Global Mean Sea Level			United States		
Year	2050	2100	2150	2050	2100	2150
Low	0.49 (0.15)	0.98 (0.3)	1.31 (0.4)	0.59 (0.18)	0.98 (0.3)	1.64 (0.5)
Intermediate-Low	0.66 (0.20)	1.64 (0.5)	2.62 (0.8)	0.75 (0.23)	1.64 (0.5)	2.95 (0.9)
Intermediate	0.92 (0.28)	3.28 (1.0)	6.23 (1.9)	0.89 (0.27)	3.28 (1.0)	6.89 (2.1)
Intermediate-High	1.21 (0.37)	4.92 (1.5)	8.86 (2.7)	1.12 (0.34)	4.92 (1.5)	8.86 (2.7)
High	1.41 (0.43)	6.56 (2.0)	12.14 (3.7)	1.38 (0.42)	6.56 (2.0)	12.46 (3.8)

TABLE 1: Reproduction of Table 4 from the Front Matter of NCA5

Considering only projections representing processes quantified with at least medium confidence, IPCC AR6 assessed global mean sea level projections for all emissions scenarios (including implausible extreme emissions scenarios) for 2100 to fall between 0.2 and 1.6 m (5th—95th percentile range). By contrast, the range of sea level rise scenarios considered by NCA5 extends to 2.0 m. Further, NCA5 fails to include plausible lower scenarios, such as 0.2 m cited by the IPCC, which also corresponds to the average rate of sea level rise over the past century.

Chapter 9 of NCA5 offers the following predictions of sea level rise:

"Under a range of potential global warming levels, average sea level along US coastlines is *likely* to be between 12 and 20 inches above 2000 sea levels in 2050 (Figure 9.2)."

The observed global sea level rise from 2000-2024 is only approximately 3.4 inches (0.28 feet). NCA5 is thus projecting a sea level rise during 2025 and 2050 along U.S. coasts that is 2.5 to 4.9 times the global rate observed during 2000-2024, an exceedingly implausible outcome. Chapter 9 further states:

“There is *high confidence* and it is *likely* that sea levels will rise about 11 inches (likely range of about 9–13 inches) between 2020 and 2050”

This implies a rate of increase more than double the rate from 2000 to 2024, again an implausible outlook. In summary, NCA5 presents future sea level rise scenarios that are not directly relatable to either SSP/RCP emissions scenarios or to plausible global warming levels. The NCA5 scenarios include two that are higher than the 95th percentile for the extreme emissions scenario RCP8.5 and include hypothesized ice sheet processes in which there is low confidence. Projections to 2050 require rates of sea level rise from 2025 to 2050 that are more than double the rate observed during 2000-2024. Further, NCA5 ascribes *high confidence* to these sea level rise projections. CWG25 Section 7.3 provides further context for USGCRP projections of extraordinary sea level rise in the next 25 years.

More generally, NCA5’s inclusion of, and even focus on, implausible extreme scenarios creates projections of alarming impacts that are very unlikely to be driven by anthropogenic warming.

7 CONFLATION OF NATURAL AND ANTHROPOGENIC CLIMATE CHANGES

NCA5’s Glossary defines “climate change” as a change in climate for any reason. This is technically correct, but at variance with IPCC usage, which also corresponds to the popular connotation, in which the term refers specifically to anthropogenically-caused change. The distinction is not academic- it is central both to attribution questions and to projections, since anthropogenic changes depend on emission rates, while natural changes are unavoidable. Having defined climate change broadly NCA5 then fails to distinguish natural and anthropogenic changes in context with the effect of implicitly over-attributing changes to greenhouse gas emissions.

The discussion on NCA5 page 2-4 begins “Human activities are changing the climate”, then goes on to list evidence for anthropogenic GHG emissions and climate warming. The next paragraph begins “Climate change is happening now in the United States. Including Alaska, the continental US has been warming about 60% faster than the planet as a whole since 1970.” The implication is that the warming of CONUS faster than the planetary average is an effect of GHG emissions. But it is an artifact of the Earth’s surface being 70 percent ocean. Since the ocean warms more slowly than land, comparison of any land surface outside the tropics with the global average would show the land surface to be warming faster than the global average, regardless of the cause of the warming.

The same page goes on to say “Climate change is already affecting people in the United States. Extreme heat was estimated to be responsible for more than 700 deaths per year between 2004 and 2018 although some estimates put heat-related mortality closer to 1,300 deaths annually.” But extreme heat has always occurred naturally, and whether natural or not, it has always been a risk to human health. As to trends, the data show that adaptation has caused the mortality burden of extreme heat to drop substantially in recent decades (CWG25 Section 10.3.1).

Consider also the NCA5 statement on precipitation cited in Section 3.2:

Many eastern regions of the country are getting wetter (Figure 2.4). Average annual precipitation from 2002-2021 was 5%-15% higher relative to the 1901-1960 average in the central and eastern US, a trend attributable to climate change.

The attribution is superfluous because the statement is a tautology by NCA5's definition of climate change. Its gratuitous inclusion effectively attributes the observed trend to greenhouse gas emissions.

Exploitation of the ambiguity inherent in the term "climate change" is endemic to NCA5. The NASEM review (pp. 23-24) flagged this problem as follows:

The draft NCA5 report frequently describes "change" but does not consistently distinguish between natural variability and climate change. This lack of clarity can be misleading for the reader by creating the misconception that some impacts that are the result of the combination of natural variability and climate change are instead solely due to climate change... it is important for NCA5 authors to accurately identify the multiple drivers of change (including global change), in addition to climate change, and accurately attribute impacts. Clearly describing impacts due to natural variability, climate change, or a combination of the two is important not only for informing policy decisions, but also for building public understand [sic] and trust in the report's messages. Climate change and natural variability should be clearly defined in the glossary and natural variability could be introduced in chapter introductions when the concept is important for understanding key messages.

This could have been easily addressed, for example by reserving the term "climate change" for anthropogenic changes and using "climate variability" for natural changes. But the NCA5 authors seemingly ignored the recommendation.

A separate but related issue is use of the term "climate change" to refer to increases in socioeconomic vulnerabilities that have anthropogenic causes unrelated to GHGs. NCA5 page 1-19 states "Climate change exacerbates inequalities." But the issue discussed is the negative correlation between neighborhood-level income and land surface temperatures in urban areas. To the extent the correlation is real, the most likely explanation is that low-income households concentrate where housing is less expensive, which might be in neighborhoods with less nearby parkland and tree cover; that has nothing to do with CO₂ emissions.

8 SUMMARY EVALUATION OF NCA5 AND RECOMMENDATIONS FOR NCA6

This chapter summarizes our evaluation of NCA5 relative to OSTP's charge: whether NCA5 (1) complied with the USGCRP's statutory obligation; (2) adheres to the core tenets of Gold Standard Science; and (3) can suitably inform federal climate and energy policy. The points made in this summary analysis refer to specific sections of this report as well as to the CWG25 report.

8.1 Compliance with USGCRP's statutory obligation

As cited in Section 1.2 of this report, the Global Change Research Act requires an assessment that:

- (1) integrates, evaluates, and interprets the findings of the [Global Change Research] Program and discusses the scientific uncertainties associated with such findings;

- (2) analyzes the effects of global change on the natural environment, agriculture, energy production and use, land and water resources, transportation, human health and welfare, human social systems, and biological diversity; and
- (3) analyzes current trends in global change, both human-induced and natural, and projects major trends for the subsequent 25 to 100 years.

We deem NCA5 to have fallen short when evaluated against these criteria because of the following major shortcomings (see indicated section for details):

- Inadequate assessment of the relevant topics in climate science and the hazard components of climate impacts (such as hurricanes and floods). NCA5 instead focuses on evaluation of societal vulnerabilities (such as flood infrastructure, access to air conditioning, etc.), “Climate Action,” and policy recommendations with a social justice emphasis (Chapter 2).
- Overconfidence in conclusions and inadequate assessment of uncertainties (Chapter 3)
- Inadequate discrimination between natural and human-induced causes of trends and impacts (Chapter 7)
- Inadequate analysis of climate trends by relying on short time periods (Chapter 6)
- Uncritical evaluation of emission scenarios and climate model simulations in making projections for the next 25 to 100 years (Chapter 6).

8.2 Adherence to the tenets of Gold Standard Science

With respect to the tenets of Gold Standard science listed in Section 1.3 of this report, we have identified the following major shortcomings in NCA5:

- **Lack of reproducibility.** In the few examples that we examined closely, we identified an instance where we could not reproduce the findings of the NCA5, a task that should require only rudimentary data analysis (Section 4.1)
- **Lack of transparency.** In many instances, the Traceable Account fails to justify the Key Finding. Metadata was not readily accessible. (Chapter 5)
- **Inadequate communication of error and uncertainty.** The Traceable Account for each Key Message provides a section on Major Uncertainties and Research Gaps; most of the accounts that we examined were superficial and uninformative. (Chapter 5)
- **Not skeptical of findings and assumptions.** The main text of the chapters is, with few exceptions, not skeptical of its findings and assumptions and does not mention dissent or disagreement. (Chapters 3 and 5)
- **Some hypotheses and Key Messages are not falsifiable.** Key Message 13.4 is but one of many examples: “Equitable Distribution of Transportation Trade-offs and Benefits Requires Community Involvement.” See discussion in Chapter 2.
- **Assumption that all changes are harmful** due to warming and additional atmospheric CO₂ (Chapter 2)
- **Inadequacy of the peer review process.** The review of the NCA5 Third Order Draft by National Academies of Science, Engineering and Medicine (NASEM) identified some of the deficiencies we have noted, but the NCA5 authors were not obligated to adopt the NASEM recommendations. More importantly, we’ve identified many other deficiencies in NCA5; the NASEM review did not point them out and thus lacked the rigor expected of NASEM reports.

8.3 Suitability for informing Federal climate and energy policy

We assess that the selection and presentation of information in NCA5 makes it an unreliable basis for U.S. climate and energy policy making. For each of the elements of knowledge characterization suitable for risk management listed in Section 1.3, here are specific examples where NCA5 falls short:

- The degree to which the assumptions made are reasonable/realistic based on background knowledge
 - NCA5 focused on implausibly extreme scenarios for emissions and sea level rise and made policy recommendations without adequate consideration of the costs
- The degree to which data/information exists and are reliable and relevant
 - NCA5's unjustified assumptions about model reliability, and its use of short time periods for analysis, does not support its high-confidence conclusions
- The degree to which there is disagreement among experts, including those from different environments or academic fields
 - While NCA5 was an interdisciplinary effort, the concerns we have raised all point to a failure to canvass or communicate the full range of evidence, including data and research findings that speak against Key Messages.
- The degree to which the phenomena involved are understood and accurate models exist
 - NCA5 is not appropriately skeptical of the ability of climate models to attribute the causes of warming and extreme events or to project future climates, especially at the regional level
- The degree to which the knowledge has been thoroughly examined with respect to unknown knowns
 - A major NCA5 shortcoming is its dismissal of natural climate variability in many contexts where it should have been a major consideration

NCA5 is also problematic for informing policy because by describing everything everywhere as threatened by climate change, frequently with exaggerated language, it fails to provide guidance for policymakers who need to prioritize and allocate scarce resources for adaptation and risk management. Likewise, it advocates for ambitious mitigation policies without a proper analysis of risks and costs. The NASEM Review of the NCA5 underscores the endemic nature of this problem - their review appears to be written by authors who share many of the biases of the NCA5 team, with an inordinate focus on social and policy issues.

NCA4 was in some respects a better policy-informing assessment than NCA5. It offered a more thorough consideration of climate science, consistently used data back to 1901, and had less of an advocacy tone. But it too engaged in some misleading hyperbole, for example in its presentation of heat extremes. NCA4's Part I said (prominently and with *Very High Confidence*) on Page 19 of the Executive Summary:

There have been marked changes in temperature extremes across the contiguous United States. The number of high temperature records set in the past two decades far exceeds the number of low temperature records.

and offered this figure in support:

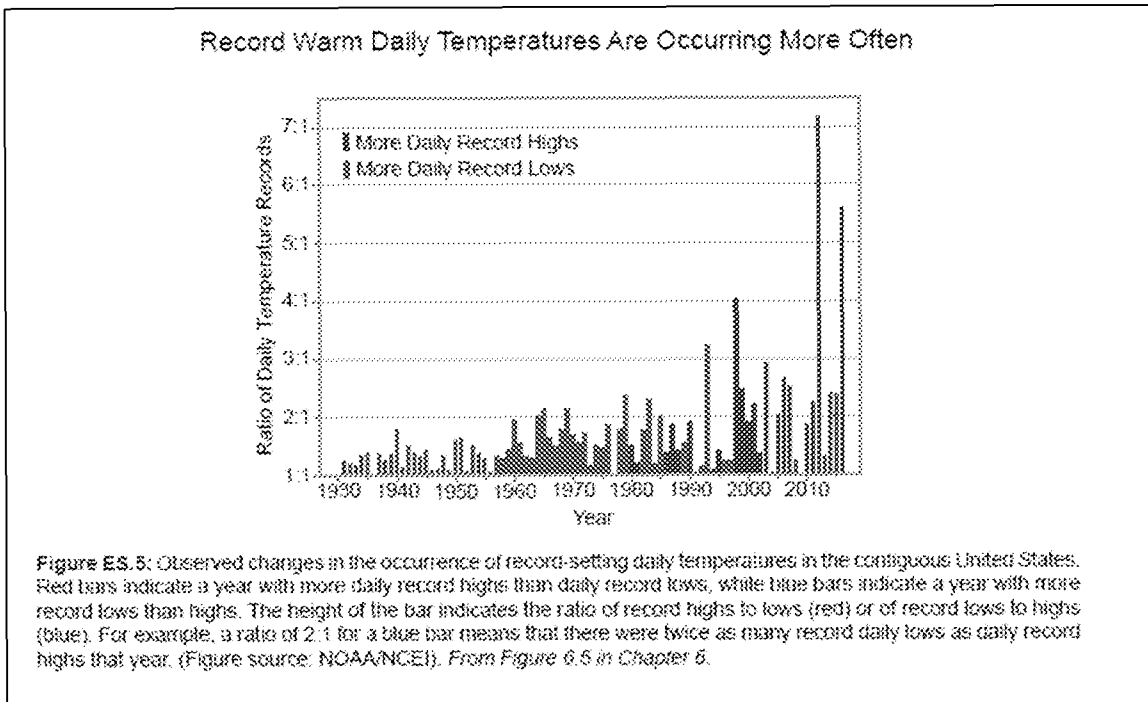


FIGURE 5: Reproduction of Figure ES.5 from NCA4

The figure appears to show that record warm daily temperatures are occurring more often. But the underlying data (see CWG Figure 6.3.3) show the opposite: extreme heat in the U.S. peaked in the 1920s and 1930s and declined thereafter. Despite its misleading title, what Figure ES.5 shows is the *ratio* of annual warm and cold event counts. Both types of extremes declined over the sample interval, but cold events declined more than warm ones, so the ratio went up. By graphing the ratio instead of simple counts, NCA4 created a visual impression opposite to what is in the data.

NCA4 also shares with NCA5 the tendency to describe everything everywhere as under threat from climate change, undermining its usefulness for policymakers. For instance, while it contains a chapter on potential adaptation responses (Volume 2 Chapter 28) it downplays the value of such planning by stating as Key Message 2 (p. 1310) that “Climate change outpaces adaptation planning: Successful adaptation has been hindered by the assumption that climate conditions are and will be similar to those in the past.”

8.4 NCA5 and the 2025 Texas Floods

To the extent an NCA should assist regional policymakers set priorities for future disaster management, we can look back at NCA4 and NCA5 and ask what relevant information they provided for the Texas Hill Country, where the tragic events of July 2025 took place. We first note that while the region in question is historically prone to flooding, the Environmental Protection Agency Climate Change Indicators record² shows decreasing flood frequency and magnitude since 1965 in that region; in other words the flood risk predates anthropogenic climate change and is not apparently exacerbated by it. Likewise daily precipitation records for nearby Austin are available back to 1873 and show no increase in annual average or maximum precipitation (see CWG25 Section 6.4 for links

² See <https://www.epa.gov/climate-indicators/climate-change-indicators-river-flooding>

to data). Hence the key contribution an NCA could make is explaining the historical context of extreme rainfall events and flood risks, rather than speculations about far future changes that might occur.

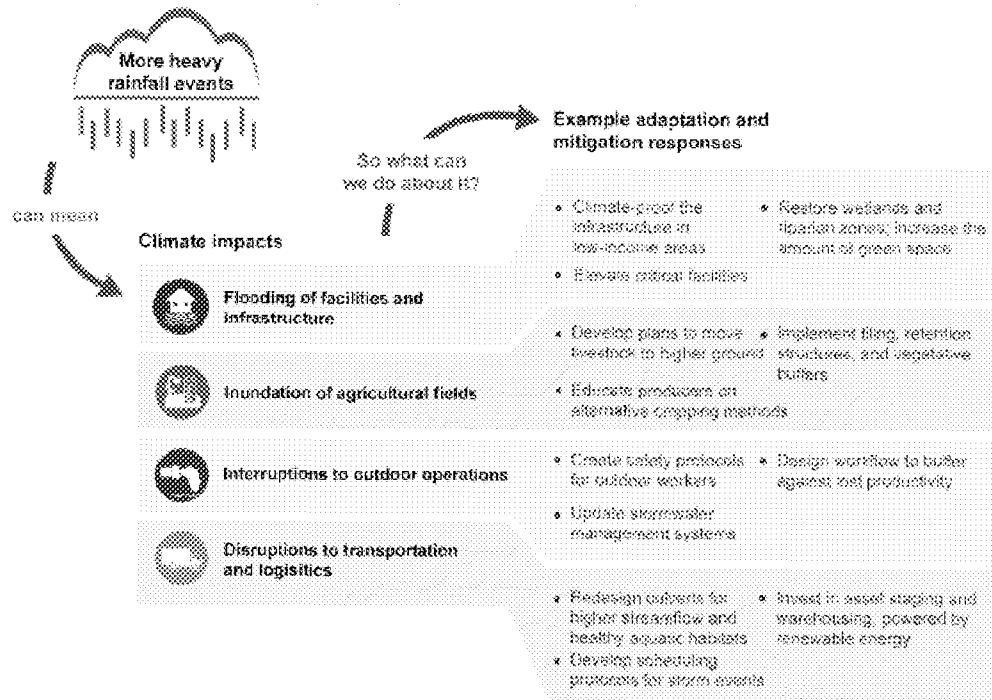
The NCA4 section on the Southern great Plains states that precipitation trends are not clearly attributed to anthropogenic forcing (pp. 213-214) and that “no formal attribution of observed flooding changes to anthropogenic forcing has been claimed” (p. 241). This supports the view that the focus of resource allocation should be adapting to the known current risk profiles of the Hill Country and that there is little to be gained by trying to forecast changes under greenhouse forcing, nor would GHG emission reductions be an effective way to reduce future flood risks. However, as noted above, NCA4 undermines its own usefulness by claiming in Volume 2 Chapter 28 that climate change is happening so quickly that historical data is uninformative for planning purposes.

NCA5 presents no data on precipitation patterns in the Southern Great Plains and no information on specific high risk zones. Instead it makes sweeping unsubstantiated claims to the effect that every climate risk is getting worse over time. For example, in Chapter 26 (Southern Great Plains) the first Key Message is (p. 26-7):

Climate change is beginning to alter how we live in the Southern Great Plains, putting us at risk from climate hazards that degrade our lands and waters, quality of life, health and well-being, and cultural interconnectedness (*high confidence*). Many climate hazards are expected to become more frequent, intense, or prolonged; to broaden in spatial extent; and to result in more people experiencing costly, deadly, or stressful climate-related conditions (*very likely, high confidence*). To address the growing risk, effective climate-resilient actions include implementing nature-based solutions; valuing Indigenous, traditional, and local knowledges; and infusing climate change solutions into community planning (*medium confidence*).

This is both inaccurate and useless for local authorities charged with setting priorities and making resource allocation decisions. The same chapter presents rainfall projections through the mid-21st century (Figure 26.10) that imply drying throughout southern TX, but no explanation is given as to how this reconciles with projections elsewhere in NCA5 (Figure 2.12 p. 2-25) of increasing extreme precipitation in the same region. The first discussion of regional trends in heavy rainfall events is on page 26-22 which focuses entirely on sports teams having to move events indoors which results in “increasing participation costs and decreasing access to sports, especially for lower-income populations.” ~~Adaptation advice consists of the following cartoon on page 26-19: DELETE THIS FIGURE, DOESN'T BELONG IN CONCLUSIONS CHAPTER~~

Resilience Actions to Address the Impacts of Heavier Rainfall Events on Businesses



Resilience actions can help businesses and industries reduce the negative consequences of more heavy rainfall events.

Figure 26.11. An increased number of heavy rainfall events affects business and industry across the Southern Great Plains through flooding of facilities and infrastructure, inundation of agricultural fields, interruptions to outdoor operations, and disruptions to transportation and logistics. The example adaptation and mitigation actions can increase resilience and reduce negative impacts. Figure credit: See figure metadata for contributors.

FIGURE 6: screenshot of NCA5 Figure 26.11

The advice is so vacuous it could have been written by someone who has never studied the topic. Combined with pervasive advocacy for renewable energy NCA5 was worse than simply unhelpful: if planners based serious decisions on it they would have misallocated resources away from potentially beneficial measures towards worthless ones. A BIT SNARKY, the ABOVE TEXT SPEAKS FOR ITSELF

8.5 Recommendations for NCA6

While we have assessed NCA5 to be scientifically inadequate and unsuitable as a basis for decision-making, one can imagine a different National Climate Assessment that meets statutory and policymaker requirements. The goal should be not to persuade, but to impart understanding by being objective, transparent and complete. A suitable NCA would be an important complement to IPCC assessments to the extent that its analysis and conclusions differ where appropriate from the “consensus” of the IPCC reports and additional topics are addressed. Such a report would promote a more open scientific discussion and a more informed policy debate.

We recommend that the NCA6 have a narrower scope than NCA5, refocusing on climate science, including natural climate variability, with topics to include:

- How the climate has varied in the past. The U.S. has the best and longest meteorological records and they should be examined and displayed in their entirety. Trend analyses should include longest periods available and employ suitable statistical methods. Local paleoclimate data should be considered where available. Analysis should demonstrate not only how the climate has varied and changed, but also regional heterogeneity. Standard, easily understandable metrics should be employed.
- The range of climatic and weather conditions, including extremes, that have occurred in the past and can reasonably be expected to occur in U.S. regions over the near future.
- A critical survey of current global and regional modeling capabilities and their suitability for regional impact assessments and projections. This would include an assessment of their ability to reproduce observed changes. It should also discuss alternative methods for generating scenario projections on regional and decadal scales, along the lines of Chapter 10 of the IPCC AR6 WGI Report.
- Assessment of the impacts of recent historical climate variability and change on ecosystems and society. Where long-term data indicate a detectable regional change, regional projections can be made for the period 2030-2050. Emissions scenarios exceeding RCP4.5/SSP2-4.5 and ECS values exceeding 4°C should not be used. Regional projections to 2100 have no credibility at this time and so should not be included in NCA6.

It is important that climate projections be assessed in context of current science capabilities. The pressures toward spatially or temporally precise projections should be resisted as the current models are nowhere up to the task (an example is discussed in CWG25 Section 5.8). In that light, the many pages of NCA5 devoted to projected regional and sectoral impacts have little value.

Given the substantial deficiencies and bias in NCA5 that we have identified, producing an objective NCA6 report with the current NCA organizational construct would be a challenge. A NASEM review could help, but only if the selected participants reflect full viewpoint diversity and do not simply mirror the assumptions and biases of past NCA teams. We regard the CWG25 report to be a good start on NCA6 in terms of scope and objectivity, including adherence to the tenets of Gold Standard Science.

More broadly, we recommend a rewrite of the Global Change Research Act. The current mandate is vague and off point, allowing successive NCA teams to interpret the mandate as they see fit. Moreover, it is becoming increasingly clear that current and foreseeable models are not fit-for-purpose to describe regional climates, let alone usefully project them for 25 to 100 years. Further, the use of the term “global change” is ambiguous and outdated.

9 REFERENCES

- Aven, Terje (2017) “Improving Risk Characterisations in Practical Situations by Highlighting Knowledge Aspects, with Applications to Risk Matrices,” *Reliability Engineering & System Safety* 167 (November 2017): 42–48
<https://www.sciencedirect.com/science/article/pii/S0951832016306950>
- Climate Working Group (2025) Impacts of Carbon Dioxide Emissions on the U.S. Climate. Washington DC: Department of Energy, May 27, 2025.
- Diffenbaugh, N.S., D. Singh, and J.S. Mankin, 2018: Unprecedented climate events: Historical changes, aspirational targets, and national commitments. *Science Advances*, 4 (2), 3354.
<https://doi.org/10.1126/sciadv.aao3354>

- Kirchmeier-Young, M.C. and X. Zhang, 2020: Human influence has intensified extreme precipitation in North America. *Proceedings of the National Academy of Sciences of the United States of America*, 117 (24), 13308-13313. <https://doi.org/10.1073/pnas.1921628117>. Supplement at https://www.pnas.org/doi/suppl/10.1073/pnas.1921628117/suppl_file/pnas.1921628117.sapp.pdf
- Knutson, Thomas and Fanrong Zeng (2018) "Model Assessment of Observed Precipitation Trends over Land Regions: Detectable Human Influences and Possible Low Bias in Model Trends" *Journal of Climate* 31(12) <https://journals.ametsoc.org/view/journals/clim/31/12/jcli-d-17-0672.1.xml>
- National Academies of Sciences, Engineering, and Medicine. 2023. *Review of the Draft Fifth National Climate Assessment*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/26757>.
- NCA4. (2017). *Climate science special report: Fourth National Climate Assessment, Volume I* (D. J. Wuebbles, D. W. Fahey, and K. A. Hibbard, Eds.). U.S. Global Change Research Program. <https://doi.org/10.7930/J0J964J6>
- NCA5. (2023). *Fifth National Climate Assessment* (A. R. Crimmins et al., Eds.). U.S. Global Change Research Program. <https://doi.org/10.7930/NCA5.2023.CH1>
- Schlund, Manuel, Axel Lauer, Pierre Gentine, Steven C. Sherwood, and Veronika Eyring (2020) Emergent constraints on equilibrium climate sensitivity in CMIP5: do they hold for CMIP6? *Earth System Dynamics* 11 1233-1258 <https://doi.org/10.5194/esd-11-1233-2020>

10 APPENDIX: CHARGE TO THE REVIEW

ABOUT THE AUTHORS

[Insert updated bios]

From: Ross McKittrick [ross.mckittrick@gmail.com]
Sent: 7/17/2025 9:40:57 PM
To: Judith Curry [curry.judith@gmail.com]; Roy W. Spencer [roywspencer@hotmail.com]; John Christy [climatemanager60@gmail.com]; Steven Koonin [steven.koonin@gmail.com]; Travis Fisher [travis.scott.fisher@gmail.com]; Josh Loucks [loucksj14@gmail.com]; Cohen, Seth [seth.cohen@hq.doe.gov]
Subject: NCA5 critique July 17 edition
Attachments: NCA5.Review.July17.[RM].docx

In the attached I have accepted all the various edits collected to this point, many of which were small and grammatical. I have made some new changes marked in Track Changes, summarized as follows.

p. 3 ES: *Framing climate policy as a morality play*: I didn't know what this meant and it would be difficult to explain in a bullet point so I think it is better to merge it into the other bullets as I have attempted to do.

Section 1.1: *We did not have access to the Public Comments and responses*: Others have in the past so we're not sure we couldn't have gotten them if we tried. More to the point even if we had had access, the proof of the pudding is in the eating. The poor quality of the final report is sufficient evidence that the review process is deficient.

We find that the NCA5 should not be relied upon... I rewrote this paragraph. The report will be read in light of the TX floods. We can't lead with a claim that NCA5 is excessively alarmist—that will be spun as us having our heads in the sand. In the aftermath of the CA wildfires and TX floods one of my concerns is NCA5 calls everything everywhere a crisis, which is as unhelpful for planning purposes as ignoring all risks. The failure to provide focus and identify adaptive priorities is a key weakness in both NCA4 and 5. Somewhere in the US there is a small area where a thousand people sleep soundly at night oblivious to a looming weather-related catastrophe that, while rare, may happen tomorrow, and if it does there will be a lot of needless death and destruction. The NCA5 does not help us find where this place is on the map and take remedial steps to save lives, because it doesn't outline the full range of known weather risks and cries wolf everywhere about speculative future risks.

Discussion of Kirchmeier-Young and Zhang p. 9 – rewritten. I found their US-only results online which really sink the NCA5 text.

Discussion of extreme precipitation Sect 4.1 – I ported details to CWG25 and to a footnote. So there are no self-citations in the reference list but we do rely on a footnote.

Sea level rise p. 18: we compare the observed **global** change over 2000-2024 to the projected **US** rate over 2025-2050. Are they equivalent? Also the trend ratios don't look right. 2000-2025 observed = 3.4 inches. Projection is 12 – 20 inches. So smallest trend for next 25 years is $(12 - 3.4) / 3.4 = 2.5x$ the recent trend and largest is $(20-3.4)/3.4 = 4.9x$ the recent trend. 2020-20205 trend is $(11-3.4)/3.4 = 2.2x$ current trend. Text modified accordingly.

Section 7 intro paragraph. Clarifying what the problem is.

8.1: I fixed the Section citations.

p. 21 *Failure to acknowledge benefits*: but Ch 9 does admit to some benefits. Problem is in Chapters 2 & 3, as we state in our own Ch 2.

Sect. 8.3: I expanded critique of NCA4 to bring the ES.5 diagram back in.

New section 8.4 to review how NCA4 and NCA5 handled the known risks in the TX Hill Country. Note: NCA4 only mentions Guadalupe River 1x (with regard to dryness in the headwaters area); NCA5 0x.

For the next round of revisions, since Steve is out of pocket until next week, I suggest Judy go next then Roy then John then Steve.

Critique of the Fifth National Climate Assessment

EXECUTIVE SUMMARY	3
1 INTRODUCTION	4
1.1 ABOUT THIS REPORT	4
1.2 ABOUT THE NATIONAL CLIMATE ASSESSMENTS	4
1.3 STANDARDS FOR ASSESSING NCA PRODUCTS	5
2 NCA5 OVERVIEW CHAPTER: ADVOCACY LANGUAGE AND UNSCIENTIFIC TONE	6
3 OVERCONFIDENCE WHEN STATING CONCLUSIONS	7
3.1 INFLATED CERTAINTY LEVELS	7
3.2 OVERSTATING FINDINGS IN UNDERLYING SOURCES	9
3.3 EXAMPLE: EMERGENT CONSTRAINTS	9
4 ARBITRARY AND AMBIGUOUS TREND ANALYSES	10
4.1 AVERAGE AND EXTREME PRECIPITATION	11
4.2 HEATWAVES	11
5 INADEQUATE TRACEABLE ACCOUNTS	14
6 OVEREMPHASIS ON EXTREME SCENARIOS	16
7 CONFLATION OF NATURAL AND ANTHROPOGENIC CLIMATE CHANGES	18
8 SUMMARY EVALUATION OF NCA5 AND RECOMMENDATIONS FOR NCA6	19
8.1 COMPLIANCE WITH USGCRP'S STATUTORY OBLIGATION	19
8.2 ADHERENCE TO THE TENETS OF GOLD STANDARD SCIENCE	20
8.3 SUITABILITY FOR INFORMING FEDERAL CLIMATE AND ENERGY POLICY	20
8.4 NCA5 AND THE 2025 TEXAS FLOODS	22
8.5 RECOMMENDATIONS FOR NCA6	24
9 REFERENCES	25
10 APPENDIX: CHARGE TO THE REVIEW	27
ABOUT THE AUTHORS	28

EXECUTIVE SUMMARY

This report critically evaluates the Fifth National Climate Assessment (NCA5), finding it an inadequate basis for climate and energy policies. A detailed review of the foundational chapters on climate science raises several key concerns:

Scientific Integrity

- An advocacy tone, particularly in the Overview chapter, that is inconsistent with scientific objectivity
- Endemic overconfidence when stating conclusions, including inflated certainty levels and overstatement of findings from underlying sources
- No mentions of dissent, disagreement or controversies
- Policy prescriptions that ignore costs and tradeoffs

Flawed methodology

- Minimal discussion of observational inadequacies
- Use of short time periods for trend analyses; lack of a consistent rationale for choosing time scales
- Attribution is implied, not dissected
- Overemphasis on extreme scenarios for future emissions and sea level rise
- Inadequate traceable accounts to support key conclusions

Inadequate Review Process

- A review by the National Academy of Sciences, Engineering, and Medicine (NASEM) failed to identify some fundamental flaws in NCA5
- The NCA5 authors failed to adopt some improvements recommended by NASEM

The report shows NCA5 to be a biased and incomplete picture of climate science that skews toward excessive climate risk. Consequently, NCA5 should not be used as basis for climate and energy policies.

1 INTRODUCTION

1.1 About this Report

This report responds to a request from the Office of Science and Technology Policy (OSTP) Director Michael Kratsios (reproduced in the Appendix) [MAY HAVE TO MODIFY THIS] that we assess the suitability of the Fifth National Climate Assessment (NCA5 2023) for informing climate and energy policies.

To conduct this assessment, we reviewed NCA5 itself, the National Academies of Science, Engineering and Medicine (NASEM) review of the Third Order NCA5 Draft, and the USGCRP responses to that review. We have drawn upon our long experience working on advisory reports, including for the NASEM, the Intergovernmental Panel on Climate Change (IPCC), and other organizations as writers, reviewers, and study leaders. We have reviewed recent scientific developments in a separate report to Energy Secretary Wright (Climate Working Group 2025) herein denoted “CWG25”.

We find that NCA5 should not be relied on for policy making as it portrays an incomplete and misleading picture of current climate variability and how climate-related risks are or are not changing over time. NCA5 was selective and incomplete in its survey of climate science. The overall effect of its biases and omissions is an unfocused and excessively dire picture of climate risk.

To support our finding, the following sections of this chapter provide some background on the National Climate Assessments and the standards by which we have assessed NCA5. Chapters 2 through 7 detail important ways in which NCA5 fails to meet those standards. Finally, Chapter 8 summarizes our evaluation of NCA5 and makes recommendations for NCA6.

1.2 About the National Climate Assessments

The U.S. Global Change Research Program (USGCRP) was established by Presidential Initiative in 1989 and mandated by Congress in the Global Change Research Act (GCRA) of 1990 to develop and coordinate “a comprehensive and integrated United States research program which will assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change.”

The National Climate Assessment (NCA) Reports evolved from the GCRA requirement to:

Prepare and submit to the President and the Congress an assessment which (1) integrates, evaluates, and interprets the findings of the Program and discusses the scientific uncertainties associated with such findings; (2) analyzes the effects of global change on the natural environment, agriculture, energy production and use, land and water resources, transportation, human health and welfare, human social systems, and biological diversity; and (3) analyzes current trends in global change, both human-induced and natural, and projects major trends for the subsequent 25 to 100 years.

The five NCA Reports to date have interpreted this mandate in different ways:

- NCA1 (2000) was a multidisciplinary effort to study and portray in regional detail the potential effects of human-induced global warming on the United States.

- NCA2 (2009) was a relatively short report that not only focused on the potential consequences of climate change but also sought to identify potential adaptation measures and identify the highest priorities for future research.
- NCA3 (2014) was an expanded effort that continued along the lines of NCA2, and was distinguished by a comprehensive review process, including a review by the National Academy of Sciences. NCA3 introduced a traceability analysis for each key finding, including a description of uncertainties.
- NCA4 (2017/2018) was a further expanded effort that was published in two volumes: I Climate Science Special Report (CSSR), and II Impacts, Risk, and Adaptation in the United States. This was the first NCA report to devote significant effort to assessing climate science.
- NCA5 (2023) returned to a single volume format, reducing discussion of climate science to a cursory two chapters, with continuing focus on regional and sectoral impacts of climate change. NCA5 expanded its remit to topics that are arguably outside the purview of the USGCRP, focusing on “Climate Action” and policy recommendations with a social justice emphasis.

These successive interpretations of the NCA are poorly aligned with the GCRA’s statutory requirements. Only NCA4 gives serious consideration to climate science, which receives the great majority of USGCRP funding, and even then NCA4 misrepresents some important points. Natural climate variability is essentially dismissed as unimportant in NCA4 and barely mentioned in NCA5 in most contexts, despite the mandate to include both human-caused and natural climate change. Most significantly, NCA5 has redirected the focus away from climate science and even the hazard elements of impacts, towards evaluation of societal vulnerabilities and advocacy for particular policy options, especially deployment of wind and solar power generation.

1.3 Standards for Assessing NCA Products

Beyond the statutory requirements stated above, another pertinent standard is President Trump’s executive order of May 23, 2025, Restoring Gold Standard Science. It enumerates some of the characteristics of good science, namely that it should be:

- i. reproducible;
- ii. transparent;
- iii. communicative of error and uncertainty;
- iv. collaborative and interdisciplinary;
- v. skeptical of its findings and assumptions;
- vi. structured for falsifiability of hypotheses;
- vii. subject to unbiased peer review;
- viii. accepting of negative results as positive outcomes; and
- ix. without conflicts of interest.

For an assessment of policy relevant science, it is also important to include statements about the strength of knowledge. The IPCC’s approach to assessing strength of knowledge is based on judgment of the available evidence and agreement among experts. But there are more sophisticated knowledge characterizations for risk management. Here are the elements according to Aven (2017):

- The degree to which the assumptions made are reasonable/realistic based on background knowledge

- The degree to which data/information exists and are reliable and relevant
- The degree to which there is disagreement among experts (including those from different environments or academic fields)
- The degree to which the phenomena involved are understood and accurate models exist
- The degree to which the knowledge has been thoroughly examined with respect to unknown knowns (issues that are known to matter but are ignored, such as, in this context, natural variability).

2 NCA5 OVERVIEW CHAPTER: ADVOCACY LANGUAGE AND UNSCIENTIFIC TONE

NCA5 Chapter 1, “Overview”, holds a prominent place in the Report since it summarizes the entire report and is the only section that many will read. Chapter 1 is marred by an activist tone, language that aggressively promotes mitigation policies, and motivated optimism. As such, this chapter adds an imprimatur of scientific authority to naïve and simplistic declarations of opinion about public policy. Here are some examples.

Chapter 1 opens with:

The more the planet warms, the greater the impacts. Without rapid and deep reductions in global greenhouse gas emissions from human activities, the risks of accelerating sea level rise, intensifying extreme weather, and other harmful climate impacts will continue to grow. Each additional increment of warming is expected to lead to more damage and greater economic losses compared to previous increments of warming, while the risk of catastrophic or unforeseen consequences also increases.

This statement presupposes that all warming is anthropogenic, that all warming is bad and causes economic damage, and that warming intensifies extreme weather. Such sweeping generalizations go well beyond what science has or can establish. The statement also refers to growing risks without reference to their magnitude – a small risk that increases might still be a small risk, and a large risk might be only incrementally worsened.

On the next page one finds:

Each additional increment of warming leads to greater risks [here it lists 7 key components of society including food security and the economy] ... Without deeper cuts in global net emissions, climate risks to the US will continue to grow... Action to limit future warming and reduce risks can have near-term benefits and opportunities: low-carbon energy jobs, Improved air quality, Health benefits, Economic benefits...”

The authors write as if climate policy does not involve trade-offs and all measures to reduce future warming will be effective and beneficial. Neither the vast body of scholarship on climate science and economics nor historical experience support such simplistic claims (CWG25). Not every additional increment of warming leads to economic harms; in fact, NCA5 Chapter 19 acknowledges that there will also be benefits. Nor is climate policy guaranteed to benefit the economy; it could impose net costs. Such misleading statements are a disservice to policymakers.

Pages 8 and 9 of the Overview promote renewable energy options by noting, correctly, that the levelized costs of wind/solar generation have fallen sharply since 2010, and so offers this rationale for pursuing deep emission reductions:

Recent growth in the capacities of wind, solar, and battery storage technologies is supported by rapidly falling costs of zero- and low-carbon energy technologies, which can support even deeper emissions reductions. For example, wind and solar energy costs dropped 70% and 90%, respectively, over the last decade, while 80% of new generation capacity in 2020 came from renewable sources.

Yet it has long been known that intermittent renewables generation must be supplemented by dispatchable generation to meet grid reliability standards, and that doing so (*e.g.*, through natural gas, fission, or storage) significantly increases the total cost of electricity. Further, there are yet unmet synchronization challenges in electrical grids with heavy penetration of wind and solar generation. NCA5 fails to acknowledge these facts. But more importantly, we see no reason for NCA5 to be discussing renewable energy technologies and economics in the context of its mandate.

Page 17 of the Overview introduces the discussion of risks from extreme weather events by saying “Harmful impacts from more frequent and severe extremes are increasing across the country.” This creates the impression that extreme weather events are worsening and that disaster losses are driven by trends in extreme weather. While the section goes on to acknowledge that some of the increase is due to increases in the exposure and value of assets at risk, it then invokes the NOAA Billion Dollar Dataset as evidence of extreme weather getting worse. Scientists have shown that this is an invalid metric (CWG25 Section 10.2) since it measures the growth of vulnerable infrastructure, not the frequency of extreme weather, and indeed NOAA has recently withdrawn the data product. Even though the dataset was still distributed by NOAA at the time of the NCA5, the report authors failed to assess it skeptically and see that it was unfit for the purpose of measuring climate trends.

Page 23 of the Overview states, in large font:

Climate changes are making it harder to maintain safe homes and healthy families; reliable public services; a sustainable economy; thriving ecosystems, cultures, and traditions; and strong communities.

This statement cannot be evaluated on scholarly grounds and so doesn’t belong in a scientific assessment report. Its prominent inclusion points not only to the willingness of NCA5 authors to promote alarm, but also the ineffectiveness of the review process in eliminating such statements.

3 OVERCONFIDENCE WHEN STATING CONCLUSIONS

3.1 Inflated certainty levels

Overconfidence in stating conclusions has been an endemic problem in NCA Reports. The authors frequently make sweeping generalizations without appropriate caveats or acknowledging uncertainties. The overconfidence begins with inflated language to describe certainty levels.

NCA5 uses specific terms to convey information about scientific confidence associated with important findings, observations and projections. The Front Matter of NCA5 states that

confidence in a finding is based on the type, amount, quality, strength, and consistency of evidence; the skill, range, and consistency of methods to detect, evaluate, attribute, and interpret climate trends; and the degree of agreement across scientific information sources.

Table 1 from the Front Matter provides calibrated language for confidence assessments:

Very high:	Strong evidence (established theory, multiple sources, well documented and accepted methods, etc.). High consensus
High:	Moderate evidence (several sources, some consistency, methods vary and/or documentation limited, etc.). Medium consensus
Medium:	Suggestive evidence (a few sources, limited consistency, methods emerging, etc.) Competing schools of thought.
Low:	Inconclusive evidence (limited sources, extrapolations, inconsistent findings, poor documentation and/or methods not tested, etc.). Disagreement or lack of opinions among experts.

This terminology is obviously inflated: *high confidence* with just moderate evidence and medium consensus; *medium confidence* with only suggestive evidence and competing schools of thought. This inflation in terminology leads to overconfidence in conclusions.

Even with this inflated terminology, NCA5 further inflates the confidence level of many of its conclusions to well beyond what the IPCC has concluded with more thorough justification, and by incorrectly applying its own standards. An example is the conclusion about anthropogenic influence on climate change, arguably one of the most important scientific statements of the report.

Key Message 3.1 Traceable Account states:

There is *very high confidence* that emissions of GHGs from human activities, fossil fuel use in particular, have unequivocally caused *all* global warming observed over the industrial era.

while the corresponding statements from IPCC AR5 and AR6 are

AR5: It is *extremely likely* that *more than half* of the observed increase in global average surface temperature from 1951 to 2010 was caused by the anthropogenic increase in greenhouse gas concentrations and other anthropogenic forcings together. (IPCC, 2013)

AR6: The *likely* range of total human-caused global surface temperature increase from 1850–1900 to 2010–2019 is 0.8°C to 1.3°C, with a best estimate of 1.07°C. It is *likely* that well-mixed GHGs contributed a warming of 1.0°C to 2.0°C, other human drivers (principally aerosols) contributed a cooling of 0.0°C to 0.8°C, natural drivers changed global surface temperature by –0.1°C to +0.1°C, and internal variability changed it by –0.2°C to +0.2°C. It is *very likely* that well-mixed GHGs were the main driver of tropospheric warming since 1979.

The IPCC AR5 and AR6 statements provide likelihood assessments but not a confidence level. While NCA5 claims with *very high confidence* that fossil fuels have unequivocally caused *all* global warming, AR5 refers to “*more than half* of the observed warming” and AR6 provides a more nuanced statement that relates to a *likely* range of warming contributed to by human drivers.

3.2 Overstating findings in underlying sources

Although we did not do a detailed audit of NCA5's use of source material, spot checks suggest a pattern of overstatement.

Chapter 2 page 11 reports on an increase in precipitation in some areas and attributes it to "climate change":

Many eastern regions of the country are getting wetter (Figure 2.4). Average annual precipitation from 2002-2021 was 5%-15% higher relative to the 1901-1960 average in the central and eastern US, a trend attributable to climate change.

NCA5 attributes the claim to Knutson and Zeng (2018). But Knutson and Zeng did not say these things nor did they analyze this particular period. For 1981-2010 they cautioned that observed changes are consistent with natural variability, and they did not claim attributable trends were observed over the United States.

As another example of overstating findings, NCA5's Chapter 2 page 18 states

There is robust evidence that human-caused warming has contributed to increases in the frequency and severity of the heaviest precipitation events across nearly 70% of the US.

This is apparently attributed to Diffenbaugh *et al.* (2018) and Kirchmeier-Young and Zhang (2020). Diffenbaugh *et al.* presented ratios of observed occurrences of extreme events to simulated occurrence rates in CMIP6 models run with only natural forcings. They report that for 79% of the U.S., extreme rainfall events are currently more frequent than in simulations, and the ratio of occurrences will rise under future warming simulations. This is not "robust" evidence of anthropogenic influence since it requires readers to assume that climate models accurately simulate regional precipitation patterns, something that the IPCC AR6 states is uncertain (AR6 WGI SPM Box SPM 1.2, SPM Section C.1.3).

Kirchmeier-Young and Zhang used three global climate models to analyze extreme 1- and 5-day events in North America. They noted large differences among the three models in their simulated precipitation changes. Attribution results for the U.S. are reported in their online Supplement (Figure S4). Across six experiments (three models and two rainfall metrics) anthropogenic influence was detected in only one case. Also both cited references began their historical observational records only in 1961. Here again this is not "robust" evidence. It is merely suggestive, particularly since other studies have found natural variability to be predominant.

3.3 Example: Emergent constraints

Some of the overconfidence expressed by NCA5 arises by omitting discussion of counterevidence in the peer reviewed literature, ignoring dissent and disagreement. An example is the topic of "emergent constraints". NCA5 Chapter 3 page 17 invokes this concept to support its claim that key uncertainties in climate model projections have been reduced:

An approach to reduce uncertainty in climate change projections has matured over the past decade. It is known as "emergent constraints." The term refers to strong statistical

relationships between highly uncertain future climate parameters and observable trends or variations in the current climate, along with a physical explanation of this relationship.

Emergent constraints appeared in the climate modeling literature as an attempt to tie climate model behavior to climate observations in hopes of generating insight into real-world equilibrium climate sensitivity (ECS). Climate models exhibit a wide range of ECS values. The idea of emergent constraints is to examine whether the models with shared sensitivity values also share a common representation of some climate process (usually related to clouds) that might influence ECS. Suppose, for example, that in low-ECS models the total cloud fraction in the tropics is strongly correlated with that in the southern midlatitudes, but in high-ECS models the correlation is weak. Then researchers could examine whether the observed correlation is strong or weak and draw a conclusion about which type of model, and therefore which ECS value, is more likely.

A problem in the emergent constraint literature is that there has been a proliferation of proposed correlations with little physical motivation. NCA5 alludes to this in the Traceable Accounts section (p. 3-40) but not in the main chapter text. As shown by Schlund *et al.* (2020), many emergent constraints patterned on CMIP5 models (Coupled Model Intercomparison Project Phase 5, used for the IPCC 5th Assessment Report) failed to work on CMIP6 models (used for the IPCC 6th Assessment Report). In other words, the correlations between ECS and cloud processes present in CMIP5 models were absent in CMIP6 models, indicating that they were likely spurious rather than clues to physical processes governing the climate system. As a result, emergent constraints estimated on CMIP5 models *increased* the uncertainty of ECS, rather than decreasing it as claimed by NCA5.

Yet NCA5 described the use of emergent constraint analysis as an advance that reduced the uncertainty of ECS and climate model projections (p. 3-38):

Emergent constraints have been widely applied to reduce the simulated spread in the climate feedbacks that shape climate sensitivity.

4 ARBITRARY AND AMBIGUOUS TREND ANALYSES

CWG25 Chapter 6 discussed the need for care in the choice of time scale when making claims about trends in extreme weather. We provided examples from analysis of river flooding, heatwaves, and extreme precipitation to show how assertions about apparent trends based on short data sets fall apart when considering longer versions of the same data sets. NCA5 uses varying time periods for trend analyses, especially in Chapter 2 (which is focused on trends), without explaining why shorter or longer intervals were chosen. For example, page 2-4 defines temperature trends over the interval since the late 1800s whereas page 3-29 presents temperature trends over 1972-2021. Page 2-11 compares rainfall over the 2002-21 versus 1901-1960 intervals, while page 2-18 uses the interval since the late 1950s to compute trends.

A further problem is that NCA5 uses the term “trend” repeatedly without indicating if it is statistically significant (*i.e.*, distinguishable from random variability); the ambiguity creates the impression all the observed changes were significant, but readers are left to speculate. All climate variables will, in principle, drift up or down over any particular time interval. Identifying the change as a trend requires showing that it is statistically significant using a variance estimator suitable for the type of data being analysed. Of particular importance is choosing a method robust to the serial correlation that is frequently present in climate data. Throughout Chapters 1 to 3, references are made to

“trends” without explaining how they were computed. The exception was on page 1-19 which refers to urban temperature trends being calculated using the Theil-Sen estimator, although that method does not seem to have been used elsewhere. The one case where reference is made to statistical significance is on Page 2-9, referring to a trend in Atmospheric Optical Depth, but there is no explanation of how significance was determined. Page 2-19 refers to regional trends in droughts being “robust” but again fails to explain how the term was defined.

4.1 Average and Extreme Precipitation

NCA5 did not continue the NCA4 precedent of using the post-1901 interval as the time scale for its precipitation discussion. Instead, it refers to changes “since the 1950s”; NCA5 Figure 2.8 suggests 1958 might be the intended start date. Under Key Message 2.2, “Extreme Events Are Becoming More Frequent and Severe”, NCA5 states (p. 2-18):

Rainfall is becoming more extreme
Since the 1950s, there has been an upward trend in heavy precipitation across the contiguous US. This increase is driven largely by more frequent precipitation extremes, with relatively smaller changes in their intensity.

In addition to our concerns that inferences about trends are contingent on choice of time scale, if the intended meaning of this statement is that positive and significant trends are found in heavy precipitation events across CONUS, we cannot reproduce it. In CWG25 Section 6.4, in addition to referencing previous analyses in the climate literature we presented analyses of daily U.S. precipitation data for the Pacific Coast, Southeast and Northeast regions, in all cases finding both considerable regional heterogeneity and that trends in various measures of extreme precipitation detectable on one time scale are often not detected on longer or shorter time scales. Additional analysis of stations in the upper Midwest confirm this pattern.¹ Moreover the NCA5 statement was at odds with evidence in the peer-reviewed literature (discussed in CWG Section 6.4) to which authors of this report drew NCA5 authors’ attention during the review process.

The following is a more accurate summary of what U.S. precipitation data show.

There are regionally heterogeneous changes in average and extreme precipitation. Positive trends in annual average rainfall and extreme events (defined either as the annual maximum or the number of exceedances of the 99th percentile value) are generally weak or non-existent when looking at samples exceeding 130 years in length. Significant trends can be found when beginning the sample in the 1950s although in most cases the trends weaken and become insignificant when looking at the post-1980 interval. This argues against attribution of changes in precipitation to anthropogenic warming.

4.2 Heatwaves

In contrast to NCA5, NCA4 examined heat extremes across the entire 20th century, pointing out that peak heat wave activity was reached in the 1930s and has decreased since then, and that recent increases are confined to areas west of the Rockies. NCA4 stated:

¹ See details at https://www.nsstc.uah.edu/data/ushcn_jrc/SI.Precipt_trends_reproducing.pdf, which provides access to data and code.

[The] warmest daily temperature of the year increased in some parts of the West over the past century, but there were decreases in almost all locations east of the Rocky Mountains. In fact, all eastern regions experienced a net decrease, most notably the Midwest (about 2.2°F [1.2°C]) and the Southeast (roughly 1.5°F [0.8°C]).

Since the mid-1960s, there has been only a very slight increase in the warmest daily temperature of the year (amidst large interannual variability). Heat waves (6-day periods with a maximum temperature above the 90th percentile for 1961–1990) increased in frequency until the mid-1930s, became considerably less common through the mid-1960s, and increased in frequency again thereafter. As with warm daily temperatures, heat wave magnitude reached a maximum in the 1930s. (NCA4 pp. 190-191)

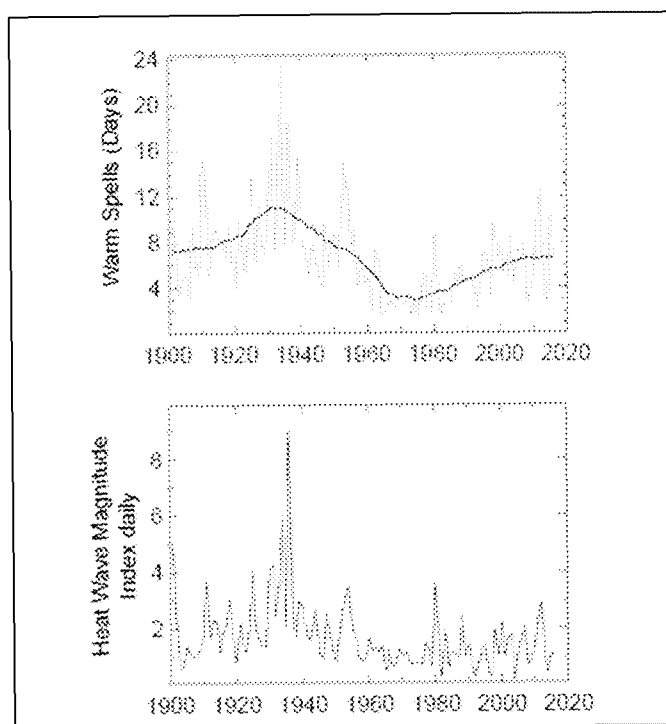


FIGURE 3. U.S. Heat waves since 1900. Reproduction of NCA4 Figure 6.4

Contrast this careful and factual language from NCA4 with NCA5 Key Message 2.2: “Extreme Events Are Becoming More Frequent and Severe.” This blanket statement is followed by NCA5 Figure 2.7 (reproduced as Figure 4 below) which shows the number of hot days, cold days and warm nights (respectively in panels a—c) over the period 2002-2021 compared to 1901-1960. Presumably these are annual counts, although this is not stated in the caption.

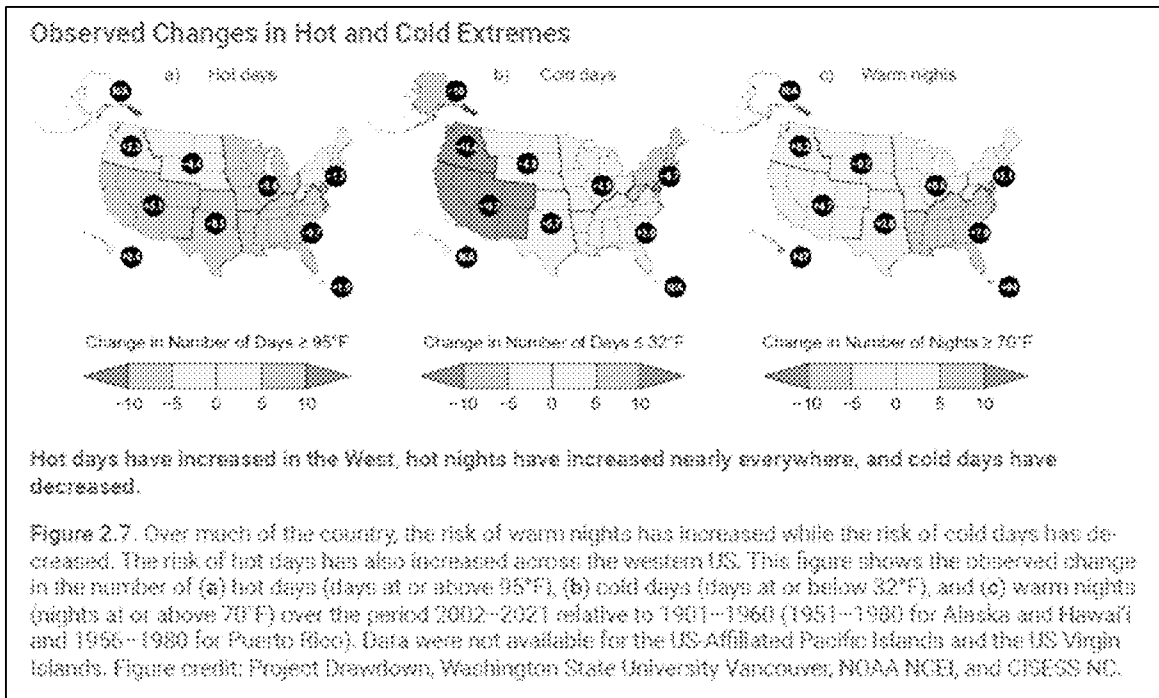


FIGURE 4: Reproduction of NCA5 Figure 2.7.

Close inspection shows that this figure actually contradicts the NCA5 Key Message with respect to heatwaves and instead reinforces the position of NCA4. Notwithstanding Key Message 2.2, the leftmost panel in NCA5 Figure 2.7 above shows that over most of CONUS the number of extreme heat days has *decreased* in recent decades compared to the prior century.

The accompanying discussion in NCA5 becomes convoluted as it appears to be aimed at supporting the Key Message despite the contrary evidence. NCA5 Chapter 2 elaborates on Key Message 2.2 by stating (page 2-16):

Observations show an increase in the severity, extent, and/or frequency of multiple types of extreme events. Heatwaves have become more common and severe in the West since the 1980s (*high confidence*).

But while it mentions the increase in hot days in the West, it fails to mention the decrease everywhere east of the Rockies. On the next page (page 2-17) it raises the comparison to the 1930s and then switches to discussing global counts:

By some measures, the most extreme heatwaves on record in the United States occurred during the Dust Bowl era of the 1930s. ... Globally such heatwaves are becoming more frequent, and in recent decades the western United States has been following those trends.

The reference to a global trend seems to be an attempt to tie heatwaves to anthropogenic climate change. But the obvious question, unaddressed by NCA5, is why one region follows the global pattern of increasing heatwaves while most of the country is trending in the opposite direction. These issues are addressed in Chapter 6 of CWG25, demonstrating that the range and magnitude of extreme temperatures are driven more by natural variability than by anthropogenic forcing. The analysis in CWG25 shows that for both (a) hot days ($\geq 95^{\circ}\text{F}$) and (b) number of days in heatwaves, the current decade is no hotter than a century ago in the U.S. Thus, the NCA5 claim that “multiday heatwaves

have become hotter, more frequent, larger, and longer lasting in recent decades,” is simply false when expanding the temporal and spatial domains to encompass all available data (Chapter 6 and Figure 6.3.6 of CWG25).

NCA5 then pointed to the dramatic Pacific Northwest heatwave of 2021. CWG25 Section 8.6.1 discusses this event in detail, reviewing the multiple peer reviewed studies that explained the unusual meteorological context was unrelated to human-caused climate change, a point omitted from the NCA5 discussion.

NCA5 finally addresses the declining heatwave trend in CONUS east of the Rockies but attempts to reframe it by focusing on urban warm spells.

[The] number of very hot days has actually decreased across the central and eastern regions due to summer cooling trends in the region (Figure 2.7; Ch. 22). This does not, however, mean the central and eastern US are not affected by heat. The impacts of extreme high temperatures are more severe if such conditions persist for several days, and overall, multiday heatwaves have become hotter, more frequent, larger, and longer lasting in recent decades. Across 50 large US cities, the US Global Change Research Program heatwave indicator (<https://www.globalchange.gov/indicators/heat-waves>) shows that the average number of heatwaves has doubled since the 1980s, and the length of the heatwave season has increased from about 40 days to about 70 days.

We discussed this part of NCA5 in CWG25 Section 6.3. The figure referenced by NCA5 uses a short time period which begins in the 1960s, the coldest decade in the last 100 years, thus suppressing any comparison to the 1930s. Further, nighttime temperatures in urban areas have increased faster than daytime temperatures (which NCA5 acknowledges), but this is a signature of urban heat islands and not a good metric of climate change. CWG25 found that the occurrence of hot days ($\geq 95^{\circ}$ F) has recently increased in the West but declined since 1899 in the remainder of the country and in the nationwide average.

5 INADEQUATE TRACEABLE ACCOUNTS

NCA3 began the practice of including a section on Traceable Accounts at the end of each chapter. This is the description from NCA5:

Each chapter concludes with a section entitled Traceable Accounts, which provides information on the overall process used to develop the chapter as well as a separate Traceable Account section for each Key Message. These Traceable Accounts describe the supporting evidence behind each Key Message, the process and rationale authors used in reaching their conclusions, and the author team’s expert assessment of the confidence in and, where applicable, likelihood of these conclusions. As such, Traceable Accounts provide information about the state of the science, document sources of uncertainty, identify research gaps, and allow traceability to data and resources.

The Traceable Accounts for each Key Message includes the following sections:

- Description of Evidence Base
- Major Uncertainties and Research Gaps

- Description of Confidence and Likelihood

The Traceable Accounts could have addressed the statutory requirement that the NCA discuss scientific uncertainties. They could also help satisfy the Executive Order for Restoring Gold Standard Science by addressing reproducibility, transparency, communication of error and uncertainty, and skepticism of findings and assumptions. However, the Traceable Accounts in NCA5's Chapters 2 and 3 are uneven, often superficial and uninformative.

An example of a deficient Traceable Account is NCA5's Key Message 2.2: "Extreme Events are Becoming More Frequent and Severe". The "Description of the Evidence Base" offers two paragraphs, the first summarizing the findings and the second generically describing the types of data that can be used for storms. "Major Uncertainties and Research Gaps" focuses on the uneven distribution across U.S. populations due to differences in exposure and vulnerability. The only limitations in data referred to are the lack of a long-term record of lightning and the lack of homogenized daily and hourly temperature data apart from reanalysis products.

But the most astonishing deficiency is in the "Description of Confidence and Likelihood." One of the statements in Key Message 2.2 is:

Hurricanes have been intensifying more rapidly since the 1980s (*high confidence*) and causing heavier rainfall and higher storm surges (*high confidence*).

The Description of Confidence and Likelihood includes the following statement:

Basic physical understanding and climate models both provide robust explanations for the links between climate change and observed changes in these extremes: this is why the authors also have high confidence that storms are delivering more rainfall and high confidence that storm surges are becoming higher.

No reference to journal publications or a specific data set is made anywhere in the chapter regarding hurricane-induced precipitation or storm surge to support this *high confidence* conclusion.

The Traceable Accounts for the various Key Findings of Chapter 3 have some substantial inconsistencies. Consider

Key Message 3-1: Human activities have caused global warming.

Confidence and Likelihood: "There is *very high confidence* that emissions of GHGs from human activities, fossil fuel use in particular, have *unequivocally* caused all global warming observed over the industrial era. There is also *very high confidence* that changes in natural climate drivers have had globally small and regionally variable long-term effects over this period."

The Uncertainties section addresses only uncertainties in radiative forcing by greenhouse gases, ignoring the great uncertainty in model responses to that forcing (CWG25 Chapters 4 and 5) In contrast, the Traceability Analysis of Key Message 3-4 ("Humans Are Changing Earth System Processes") raises the problem that relatively little is known about the role of natural variability at the regional scale. From its Description of Evidence Base:

In the last decade, there has been increasing recognition of the role of regional-scale natural variability in the past and future evolution of climate, as well as the fact that regional natural variability signals can be competitive with forced anthropogenic signals.

And from its Major Uncertainties and Research Gaps:

For example, the true natural variability of the climate system on decadal to centennial timescales could be larger than what we estimate from GCMs, which would further increase the irreducible uncertainty stemming from natural variability.

These statements are among the most scientifically credible in the entire NCA5 and they directly undercut the confidence assigned to Key Message 3-1.

There is also a generic problem in tracing NCA5's Traceable Accounts. The Front Matter of NCA5 states:

Each figure and some tables are accompanied by a metadata survey, which can be accessed in the online version of the report by clicking on the eyeball icon above the figure or table (see the table below for explanations of additional icons used throughout the report). The metadata survey describes data sources, figure or table development methods, copyright information, and other important documentation.

Clicking on the 'eyeball' icon does not reveal the metadata information; instead a "Contact Us" email appears, addressed to the USGCRP. This is an inadequate way to archive the metadata information.

In summary, the Traceable Analyses examined here, with few exceptions, fail to meet the stated objectives of the NCA.

6 OVEREMPHASIS ON EXTREME SCENARIOS

To respond to the GCRA mandate to "project major trends for the subsequent 25 to 100 years," NCA5 relies on projections of future climate change based on estimates of future emissions (the so-called SSP scenarios) and/or specified levels of radiative forcing (the RCP scenarios). For the most part, NCA5 uses scenarios developed for the IPCC Assessment Reports.

CWG25 Section 3.2.1 presented a critical assessment of past and current IPCC scenario envelopes, showing that they have tended to overshoot observed emissions. IPCC AR6 published in 2021 stated that "The likelihood of high-emission scenarios like RCP8.5 and SSP5-8.5 is considered low in light of recent energy sector developments." and that same year UN Climate Negotiators (COP) stopped using scenarios above 4.5.

NCA5 makes the following observations about the scenarios they use:

NCA5 authors were advised to assess the full range of scenarios available. (Front Matter)

Scenarios of future emissions and land-use change are developed as plausible alternatives, but no relative likelihood is attached to them. Some recent studies, however, have argued that

the highest scenario, SSP5-8.5, is no longer plausible without a reversal of current trends in the adoption of renewables and energy efficiency. (Key Message 3.3 Traceable Analysis)

Despite acknowledging the issue, NCA5 otherwise ignored the problem. A keyword search of NCA5 of mentions of RCP/SSP scenarios finds over 50% referred to the extreme emissions scenarios RCP8.5/SSP5-8.5. Further, nine NCA5 figures (5.2, 6.9, 7.4, 11.3, 14.6, 22.13, 22.19, 27.9, 29.13) included *only* the 8.5 scenarios.

The problem of relying on extreme scenarios is particularly acute for NCA5's sea level rise projections. The sea level rise scenarios used in NCA5 do not relate directly to the SSP emissions scenarios, but rather to specified amounts of sea level rise by 2100. Table 4 of NCA5's "Guide to Using this Report" reproduced below shows that Low relates to 0.3 m (0.98 feet), Intermediate-Low relates to 0.5 m (1.64 feet), Intermediate relates to 1.0 m (3.28 feet), Intermediate-High relates to 1.5 m (4.92 feet), and High relates to 2.0 m (6.56 feet).

Table 4. Descriptive Terms for Common Sea Level Rise Scenarios Used in NCA5						
Future global mean sea level rise and sea level rise along United States coastline are shown for five scenarios in feet (and meters), relative to a 2000 baseline. The US values shown in the right half of the table are averaged across the US coastal regions, including the contiguous US, Alaska, Hawaii and the US-Affiliated Pacific Islands, and the US Caribbean. The national values shown in the table differ substantially from regional values. For example, sea level rise is higher in the Gulf Coast and lower or even negative in some parts of Alaska. In the next 30 years (2020–2050), sea level along the contiguous US coasts is expected to rise 0.92 feet (0.28 m), the same amount of sea level rise observed over the last 100 years (1920–2020). See Chapter 9 for regional sea level information. Adapted from Sweet et al. 2022.”						
Sea Level Rise Scenario Descriptor	Global Mean Sea Level			United States		
Year	2050	2100	2150	2050	2100	2150
Low	0.49 (0.15)	0.98 (0.3)	1.31 (0.4)	0.59 (0.18)	0.98 (0.3)	1.64 (0.5)
Intermediate-Low	0.66 (0.20)	1.64 (0.5)	2.62 (0.8)	0.75 (0.23)	1.64 (0.5)	2.95 (0.9)
Intermediate	0.92 (0.28)	3.28 (1.0)	6.23 (1.9)	0.89 (0.27)	3.28 (1.0)	6.89 (2.1)
Intermediate-High	1.21 (0.37)	4.92 (1.5)	8.86 (2.7)	1.12 (0.34)	4.92 (1.5)	8.86 (2.7)
High	1.41 (0.43)	6.56 (2.0)	12.14 (3.7)	1.38 (0.42)	6.56 (2.0)	12.46 (3.8)

TABLE 1: Reproduction of Table 4 from the Front Matter of NCA5

Considering only projections representing processes quantified with at least medium confidence, IPCC AR6 assessed global mean sea level projections for all emissions scenarios (including implausible extreme emissions scenarios) for 2100 to fall between 0.2 and 1.6 m (5th–95th percentile range). By contrast, the range of sea level rise scenarios considered by NCA5 extends to 2.0 m. Further, NCA5 fails to include plausible lower scenarios, such as 0.2 m cited by the IPCC, which also corresponds to the average rate of sea level rise over the past century.

Chapter 9 of NCA5 offers the following predictions of sea level rise:

“Under a range of potential global warming levels, average sea level along US coastlines is *likely* to be between 12 and 20 inches above 2000 sea levels in 2050 (Figure 9.2).”

The observed global sea level rise from 2000-2024 is only approximately 3.4 inches (0.28 feet). NCA5 is thus projecting a sea level rise during 2025 and 2050 along U.S. coasts that is 2.5 to 4.9 times the global rate observed during 2000-2024, an exceedingly implausible outcome. Chapter 9 further states:

“There is *high confidence* and it is *likely* that sea levels will rise about 11 inches (likely range of about 9–13 inches) between 2020 and 2050”

This implies a rate of increase more than double the rate from 2000 to 2024, again an implausible outlook. In summary, NCA5 presents future sea level rise scenarios that are not directly relatable to either SSP/RCP emissions scenarios or to plausible global warming levels. The NCA5 scenarios include two that are higher than the 95th percentile for the extreme emissions scenario RCP8.5 and include hypothesized ice sheet processes in which there is low confidence. Projections to 2050 require rates of sea level rise from 2025 to 2050 that are more than double the rate observed during 2000-2024. Further, NCA5 ascribes *high confidence* to these sea level rise projections. CWG25 Section 7.3 provides further context for USGCRP projections of extraordinary sea level rise in the next 25 years.

More generally, NCA5’s inclusion of, and even focus on, implausible extreme scenarios creates projections of alarming impacts that are very unlikely to be driven by anthropogenic warming.

7 CONFLATION OF NATURAL AND ANTHROPOGENIC CLIMATE CHANGES

NCA5’s Glossary defines “climate change” as a change in climate for any reason. This is technically correct, but at variance with IPCC usage, which also corresponds to the popular connotation, in which the term refers specifically to anthropogenically-caused change. The distinction is not academic- it is central both to attribution questions and to projections, since anthropogenic changes depend on emission rates, while natural changes are unavoidable. Having defined climate change broadly NCA5 then fails to distinguish natural and anthropogenic changes in context with the effect of implicitly over-attributing changes to greenhouse gas emissions.

The discussion on NCA5 page 2-4 begins “Human activities are changing the climate”, then goes on to list evidence for anthropogenic GHG emissions and climate warming. The next paragraph begins “Climate change is happening now in the United States. Including Alaska, the continental US has been warming about 60% faster than the planet as a whole since 1970.” The implication is that the warming of CONUS faster than the planetary average is an effect of GHG emissions. But it is an artifact of the Earth’s surface being 70 percent ocean. Since the ocean warms more slowly than land, comparison of any land surface outside the tropics with the global average would show the land surface to be warming faster than the global average, regardless of the cause of the warming.

The same page goes on to say “Climate change is already affecting people in the United States. Extreme heat was estimated to be responsible for more than 700 deaths per year between 2004 and 2018 although some estimates put heat-related mortality closer to 1,300 deaths annually.” But extreme heat has always occurred naturally, and whether natural or not, it has always been a risk to human health. As to trends, the data show that adaptation has caused the mortality burden of extreme heat to drop substantially in recent decades (CWG25 Section 10.3.1).

Consider also the NCA5 statement on precipitation cited in Section 3.2:

Many eastern regions of the country are getting wetter (Figure 2.4). Average annual precipitation from 2002-2021 was 5%-15% higher relative to the 1901-1960 average in the central and eastern US, a trend attributable to climate change.

The attribution is superfluous because the statement is a tautology by NCA5's definition of climate change. Its gratuitous inclusion effectively attributes the observed trend to greenhouse gas emissions.

Exploitation of the ambiguity inherent in the term "climate change" is endemic to NCA5. The NASEM review (pp. 23-24) flagged this problem as follows:

The draft NCA5 report frequently describes "change" but does not consistently distinguish between natural variability and climate change. This lack of clarity can be misleading for the reader by creating the misconception that some impacts that are the result of the combination of natural variability and climate change are instead solely due to climate change... it is important for NCA5 authors to accurately identify the multiple drivers of change (including global change), in addition to climate change, and accurately attribute impacts. Clearly describing impacts due to natural variability, climate change, or a combination of the two is important not only for informing policy decisions, but also for building public understand [sic] and trust in the report's messages. Climate change and natural variability should be clearly defined in the glossary and natural variability could be introduced in chapter introductions when the concept is important for understanding key messages.

This could have been easily addressed, for example by reserving the term "climate change" for anthropogenic changes and using "climate variability" for natural changes. But the NCA5 authors seemingly ignored the recommendation.

A separate but related issue is use of the term "climate change" to refer to increases in socioeconomic vulnerabilities that have anthropogenic causes unrelated to GHGs. NCA5 page 1-19 states "Climate change exacerbates inequalities." But the issue discussed is the negative correlation between neighborhood-level income and land surface temperatures in urban areas. To the extent the correlation is real, the most likely explanation is that low-income households concentrate where housing is less expensive, which might be in neighborhoods with less nearby parkland and tree cover; that has nothing to do with CO₂ emissions.

8 SUMMARY EVALUATION OF NCA5 AND RECOMMENDATIONS FOR NCA6

This chapter summarizes our evaluation of NCA5 relative to OSTP's charge: whether NCA5 (1) complied with the USGCRP's statutory obligation; (2) adheres to the core tenets of Gold Standard Science; and (3) can suitably inform federal climate and energy policy. The points made in this summary analysis refer to specific sections of this report as well as to the CWG25 report.

8.1 Compliance with USGCRP's statutory obligation

As cited in Section 1.2 of this report, the Global Change Research Act requires an assessment that:

- (1) integrates, evaluates, and interprets the findings of the [Global Change Research] Program and discusses the scientific uncertainties associated with such findings;

- (2) analyzes the effects of global change on the natural environment, agriculture, energy production and use, land and water resources, transportation, human health and welfare, human social systems, and biological diversity; and
- (3) analyzes current trends in global change, both human-induced and natural, and projects major trends for the subsequent 25 to 100 years.

We deem NCA5 to have fallen short when evaluated against these criteria because of the following major shortcomings (see indicated section for details):

- Inadequate assessment of the relevant topics in climate science and the hazard components of climate impacts (such as hurricanes and floods). NCA5 instead focuses on evaluation of societal vulnerabilities (such as flood infrastructure, access to air conditioning, etc.), “Climate Action,” and policy recommendations with a social justice emphasis (Chapter 2).
- Overconfidence in conclusions and inadequate assessment of uncertainties (Chapter 3)
- Inadequate discrimination between natural and human-induced causes of trends and impacts (Chapter 7)
- Inadequate analysis of climate trends by relying on short time periods (Chapter 6)
- Uncritical evaluation of emission scenarios and climate model simulations in making projections for the next 25 to 100 years (Chapter 6).

8.2 Adherence to the tenets of Gold Standard Science

With respect to the tenets of Gold Standard science listed in Section 1.3 of this report, we have identified the following major shortcomings in NCA5:

- **Lack of reproducibility.** In the few examples that we examined closely, we identified an instance where we could not reproduce the findings of the NCA5, a task that should require only rudimentary data analysis (Section 4.1)
- **Lack of transparency.** In many instances, the Traceable Account fails to justify the Key Finding. Metadata was not readily accessible. (Chapter 5)
- **Inadequate communication of error and uncertainty.** The Traceable Account for each Key Message provides a section on Major Uncertainties and Research Gaps; most of the accounts that we examined were superficial and uninformative. (Chapter 5)
- **Not skeptical of findings and assumptions.** The main text of the chapters is, with few exceptions, not skeptical of its findings and assumptions and does not mention dissent or disagreement. (Chapters 3 and 5)
- **Some hypotheses and Key Messages are not falsifiable.** Key Message 13.4 is but one of many examples: “Equitable Distribution of Transportation Trade-offs and Benefits Requires Community Involvement.” See discussion in Chapter 2.
- **Assumption that all changes are harmful** due to warming and additional atmospheric CO₂ (Chapter 2)
- **Inadequacy of the peer review process.** The review of the NCA5 Third Order Draft by National Academies of Science, Engineering and Medicine (NASEM) identified some of the deficiencies we have noted, but the NCA5 authors were not obligated to adopt the NASEM recommendations. More importantly, we’ve identified many other deficiencies in NCA5; the NASEM review did not point them out and thus lacked the rigor expected of NASEM reports.

8.3 Suitability for informing Federal climate and energy policy

We assess that the selection and presentation of information in NCA5 makes it an unreliable basis for U.S. climate and energy policy making. For each of the elements of knowledge characterization suitable for risk management listed in Section 1.3, here are specific examples where NCA5 falls short:

- The degree to which the assumptions made are reasonable/realistic based on background knowledge
 - NCA5 focused on implausibly extreme scenarios for emissions and sea level rise and made policy recommendations without adequate consideration of the costs
- The degree to which data/information exists and are reliable and relevant
 - NCA5's unjustified assumptions about model reliability, and its use of short time periods for analysis, does not support its high-confidence conclusions
- The degree to which there is disagreement among experts, including those from different environments or academic fields
 - While NCA5 was an interdisciplinary effort, the concerns we have raised all point to a failure to canvass or communicate the full range of evidence, including data and research findings that speak against Key Messages.
- The degree to which the phenomena involved are understood and accurate models exist
 - NCA5 is not appropriately skeptical of the ability of climate models to attribute the causes of warming and extreme events or to project future climates, especially at the regional level
- The degree to which the knowledge has been thoroughly examined with respect to unknown knowns
 - A major NCA5 shortcoming is its dismissal of natural climate variability in many contexts where it should have been a major consideration

NCA5 is also problematic for informing policy because by describing everything everywhere as threatened by climate change, frequently with exaggerated language, it fails to provide guidance for policymakers who need to prioritize and allocate scarce resources for adaptation and risk management. Likewise, it advocates for ambitious mitigation policies without a proper analysis of risks and costs. The NASEM Review of the NCA5 underscores the endemic nature of this problem - their review appears to be written by authors who share many of the biases of the NCA5 team, with an inordinate focus on social and policy issues.

NCA4 was in some respects a better policy-informing assessment than NCA5. It offered a more thorough consideration of climate science, consistently used data back to 1901, and had less of an advocacy tone. But it too engaged in some misleading hyperbole, for example in its presentation of heat extremes. NCA4's Part I said (prominently and with *Very High Confidence*) on Page 19 of the Executive Summary:

There have been marked changes in temperature extremes across the contiguous United States. The number of high temperature records set in the past two decades far exceeds the number of low temperature records.

and offered this figure in support:

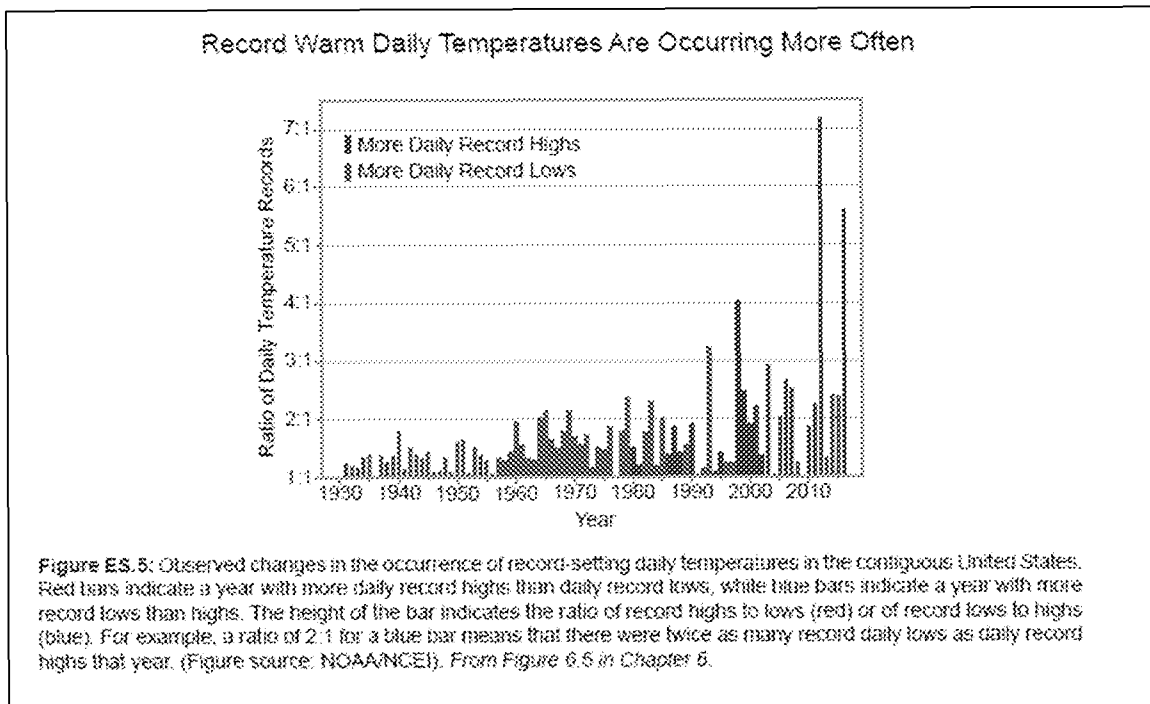


FIGURE 5: Reproduction of Figure ES.5 from NCA4

The figure appears to show that record warm daily temperatures are occurring more often. But the underlying data (see CWG Figure 6.3.3) show the opposite: extreme heat in the U.S. peaked in the 1920s and 1930s and declined thereafter. Despite its misleading title, what Figure ES.5 shows is the *ratio* of annual warm and cold event counts. Both types of extremes declined over the sample interval, but cold events declined more than warm ones, so the ratio went up. By graphing the ratio instead of simple counts, NCA4 created a visual impression opposite to what is in the data.

NCA4 also shares with NCA5 the tendency to describe everything everywhere as under threat from climate change, undermining its usefulness for policymakers. For instance, while it contains a chapter on potential adaptation responses (Volume 2 Chapter 28) it downplays the value of such planning by stating as Key Message 2 (p. 1310) that “Climate change outpaces adaptation planning: Successful adaptation has been hindered by the assumption that climate conditions are and will be similar to those in the past.”

8.4 NCA5 and the 2025 Texas Floods

To the extent an NCA should assist regional policymakers set priorities for future disaster management we can look back at NCA4 and NCA5 and ask what information they provided for the Texas Hill Country, where the tragic events of July 2025 took place. We first note that while the region in question is historically prone to flooding, the Environmental Protection Agency Climate Change Indicators record² shows decreasing flood frequency and magnitude since 1965 in that region, in other words the flood risk predates anthropogenic climate change and is not apparently exacerbated by it. Likewise daily precipitation records for nearby Austin are available back to 1873 and show no increase in annual average or maximum precipitation (see CWG25 Section 6.4 for links to data).

² See <https://www.epa.gov/climate-indicators/climate-change-indicators-river-flooding>

Hence the key contribution an NCA could make is explaining the historical context of extreme rainfall events and flood risks, rather than speculations about far future changes that might occur.

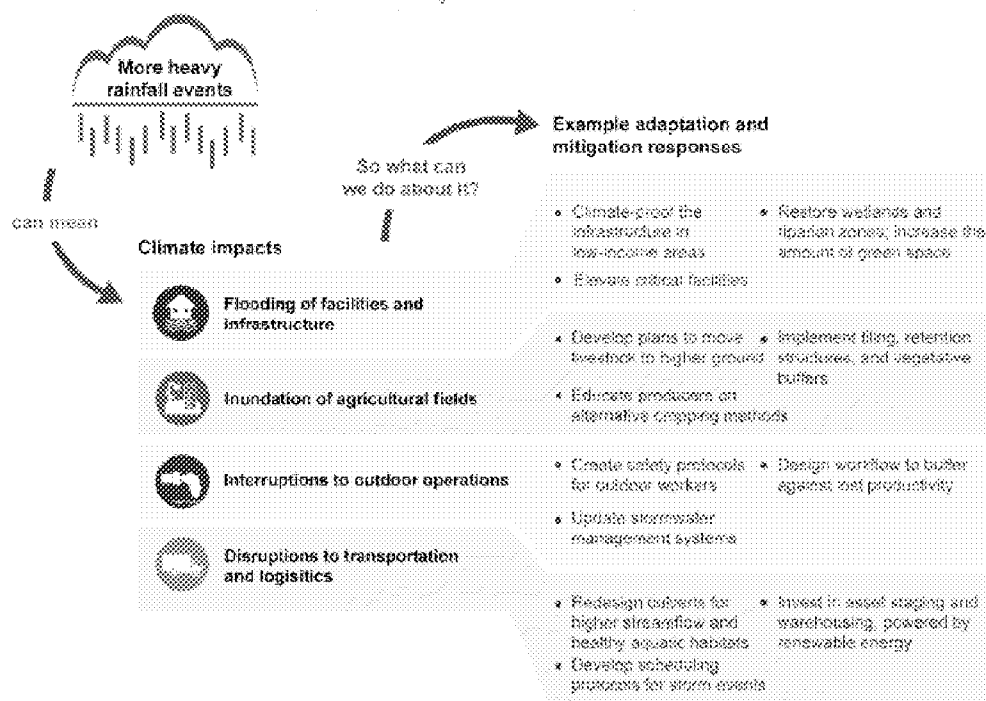
The NCA4 section on the Southern great Plains states that precipitation trends are not clearly attributed to anthropogenic forcing (pp. 213-214) and that “no formal attribution of observed flooding changes to anthropogenic forcing has been claimed” (p. 241). This supports the view that the focus of resource allocation should be adapting to the known current risk profiles of the Hill Country and that there is little to be gained by trying to forecast changes under greenhouse forcing, nor would GHG emission reductions be an effective way to reduce future flood risks. However, as noted above, NCA4 undermines its own usefulness by claiming in Volume 2 Chapter 28 that climate change is happening so quickly that historical data is uninformative for planning purposes.

NCA5 presents no data on precipitation patterns in the Southern Great Plains and no information on specific high risk zones. Instead it makes sweeping unsubstantiated claims to the effect that every climate risk is getting worse over time. For example, in Chapter 26 (Southern Great Plains) the first Key Message is (p. 26-7):

Climate change is beginning to alter how we live in the Southern Great Plains, putting us at risk from climate hazards that degrade our lands and waters, quality of life, health and well-being, and cultural interconnectedness (*high confidence*). Many climate hazards are expected to become more frequent, intense, or prolonged; to broaden in spatial extent; and to result in more people experiencing costly, deadly, or stressful climate-related conditions (*very likely, high confidence*). To address the growing risk, effective climate-resilient actions include implementing nature-based solutions; valuing Indigenous, traditional, and local knowledges; and infusing climate change solutions into community planning (*medium confidence*).

This is both inaccurate and useless for local authorities charged with setting priorities and making resource allocation decisions. The same chapter presents rainfall projections through the mid-21st century (Figure 26.10) that imply drying throughout southern TX, but no explanation is given as to how this reconciles with projections elsewhere in NCA5 (Figure 2.12 p. 2-25) of increasing extreme precipitation in the same region. The first discussion of regional trends in heavy rainfall events is on page 26-22 which focuses entirely on sports teams having to move events indoors which results in “increasing participation costs and decreasing access to sports, especially for lower-income populations.” Adaptation advice consists of the following cartoon on page 26-19:

Resilience Actions to Address the Impacts of Heavier Rainfall Events on Businesses



Resilience actions can help businesses and industries reduce the negative consequences of more heavy rainfall events.

Figure 26.11. An increased number of heavy rainfall events affects business and industry across the Southern Great Plains through flooding of facilities and infrastructure, inundation of agricultural fields, interruptions to outdoor operations, and disruptions to transportation and logistics. The example adaptation and mitigation actions can increase resilience and reduce negative impacts. Figure credit: See figure metadata for contributors.

FIGURE 6: screenshot of NCA5 Figure 26.11

The advice is so vacuous it could have been written by someone who has never studied the topic. Combined with pervasive advocacy for renewable energy NCA5 was worse than simply unhelpful: if planners based serious decisions on it they would have misallocated resources away from potentially beneficial measures towards worthless ones.

8.5 Recommendations for NCA6

While we have assessed NCA5 to be scientifically inadequate and unsuitable as a basis for decision-making, one can imagine a different National Climate Assessment that meets statutory and policymaker requirements. The goal should be not to persuade, but to impart understanding by being objective, transparent and complete. A suitable NCA would be an important complement to IPCC assessments to the extent that its analysis and conclusions differ where appropriate from the “consensus” of the IPCC reports and additional topics are addressed. Such a report would promote a more open scientific discussion and a more informed policy debate.

We recommend that the NCA6 have a narrower scope than NCA5, refocusing on climate science, including natural climate variability, with topics to include:

- How the climate has varied in the past. The U.S. has the best and longest meteorological records and they should be examined and displayed in their entirety. Trend analyses should include longest periods available and employ suitable statistical methods. Local paleoclimate data should be considered where available. Analysis should demonstrate not only how the climate has varied and changed, but also regional heterogeneity. Standard, easily understandable metrics should be employed.
- The range of climatic and weather conditions, including extremes, that have occurred in the past and can reasonably be expected to occur in U.S. regions over the near future.
- A critical survey of current global and regional modeling capabilities and their suitability for regional impact assessments and projections. This would include an assessment of their ability to reproduce observed changes. It should also discuss alternative methods for generating scenario projections on regional and decadal scales, along the lines of Chapter 10 of the IPCC AR6 WGI Report.
- Assessment of the impacts of recent historical climate variability and change on ecosystems and society. Where long-term data indicate a detectable regional change, regional projections can be made for the period 2030-2050. Emissions scenarios exceeding RCP4.5/SSP2-4.5 and ECS values exceeding 4°C should not be used. Regional projections to 2100 have no credibility at this time and so should not be included in NCA6.

It is important that climate projections be assessed in context of current science capabilities. The pressures toward spatially or temporally precise projections should be resisted as the current models are nowhere up to the task (an example is discussed in CWG25 Section 5.8). In that light, the many pages of NCA5 devoted to projected regional and sectoral impacts have little value.

Given the substantial deficiencies and bias in NCA5 that we have identified, producing an objective NCA6 report with the current NCA organizational construct would be a challenge. A NASEM review could help, but only if the selected participants reflect full viewpoint diversity and do not simply mirror the assumptions and biases of past NCA teams. We regard the CWG25 report to be a good start on NCA6 in terms of scope and objectivity, including adherence to the tenets of Gold Standard Science.

More broadly, we recommend a rewrite of the Global Change Research Act. The current mandate is vague and off point, allowing successive NCA teams to interpret the mandate as they see fit. Moreover, it is becoming increasingly clear that current and foreseeable models are not fit-for-purpose to describe regional climates, let alone usefully project them for 25 to 100 years. Further, the use of the term “global change” is ambiguous and outdated.

9 REFERENCES

- Aven, Terje (2017) “Improving Risk Characterisations in Practical Situations by Highlighting Knowledge Aspects, with Applications to Risk Matrices,” *Reliability Engineering & System Safety* 167 (November 2017): 42–48
<https://www.sciencedirect.com/science/article/pii/S0951832016306950>
- Climate Working Group (2025) Impacts of Carbon Dioxide Emissions on the U.S. Climate. Washington DC: Department of Energy, May 27, 2025.
- Diffenbaugh, N.S., D. Singh, and J.S. Mankin, 2018: Unprecedented climate events: Historical changes, aspirational targets, and national commitments. *Science Advances*, 4 (2), 3354.
<https://doi.org/10.1126/sciadv.aao3354>

- Kirchmeier-Young, M.C. and X. Zhang, 2020: Human influence has intensified extreme precipitation in North America. *Proceedings of the National Academy of Sciences of the United States of America*, 117 (24), 13308-13313. <https://doi.org/10.1073/pnas.1921628117>. Supplement at https://www.pnas.org/doi/suppl/10.1073/pnas.1921628117/suppl_file/pnas.1921628117.sapp.pdf
- Knutson, Thomas and Fanrong Zeng (2018) "Model Assessment of Observed Precipitation Trends over Land Regions: Detectable Human Influences and Possible Low Bias in Model Trends" *Journal of Climate* 31(12) <https://journals.ametsoc.org/view/journals/clim/31/12/jcli-d-17-0672.1.xml>
- National Academies of Sciences, Engineering, and Medicine. 2023. *Review of the Draft Fifth National Climate Assessment*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/26757>.
- NCA4. (2017). *Climate science special report: Fourth National Climate Assessment, Volume I* (D. J. Wuebbles, D. W. Fahey, and K. A. Hibbard, Eds.). U.S. Global Change Research Program. <https://doi.org/10.7930/J0J964J6>
- NCA5. (2023). *Fifth National Climate Assessment* (A. R. Crimmins et al., Eds.). U.S. Global Change Research Program. <https://doi.org/10.7930/NCA5.2023.CH1>
- Schlund, Manuel, Axel Lauer, Pierre Gentine, Steven C. Sherwood, and Veronika Eyring (2020) Emergent constraints on equilibrium climate sensitivity in CMIP5: do they hold for CMIP6? *Earth System Dynamics* 11 1233-1258 <https://doi.org/10.5194/esd-11-1233-2020>

10 APPENDIX: CHARGE TO THE REVIEW

ABOUT THE AUTHORS

[Insert updated bios]

From: John Christy <climateman60@gmail.com>
Sent: Wednesday, May 7, 2025 5:55 PM
To: Travis Fisher
Cc: Roy Spencer; Judith Curry; Steven Koonin; Ross McKittrick
Subject: Re: May 8 meeting

Travis

I should be there.

John C.

Sent from my iPhone

On May 7, 2025, at 10:49 AM, Travis Fisher <travis.scott.fisher@gmail.com> wrote:

Hi all,

Sorry to give you a moving target, but the latest word is that the Secretary's schedule isn't clear until 4 p.m. ET tomorrow. We should have 30 minutes with him (4 p.m. to 4:30 p.m. ET), and I'll work to set up an MS Teams video conference or a phone line you all can call into.

Best,
Travis

On Wed, May 7, 2025 at 12:39 PM Roy Spencer <roywspencer@hotmail.com> wrote:
For your entertainment and viewing pleasure, here's my blog response, which links to this morning's Politico article.

-Roy

<https://www.drroyspencer.com/2025/05/politicos-hit-piece-on-me-and-energy-secretary-wright/>

From: Travis Fisher <travis.scott.fisher@gmail.com>
Sent: Wednesday, May 7, 2025 10:37 AM
To: Judith Curry <curry.judith@gmail.com>
Cc: Roy Spencer <roywspencer@hotmail.com>; Steven Koonin <steven.koonin@gmail.com>; John Christy <climateman60@gmail.com>; Ross McKittrick <ross.mckittrick@gmail.com>
Subject: Re: Glossary

I'd be happy to take on the next version of the glossary. You don't need a PhD to do that, and I'm happy to take anything like that off your hands!

On Wed, May 7, 2025 at 10:31 AM Judith Curry <curry.judith@gmail.com> wrote:

thx for doing this. There are alot of acronyms used in the various chapters that should be included also

On Wed, May 7, 2025 at 3:45 AM Roy Spencer <roywspencer@hotmail.com> wrote:
Attached is my first cut at a glossary, 64 terms so far based upon my reading of the chapters.

I've omitted obvious things like EPA, CO2, NOAA, NASA...

I'm sure I missed a few terms, and feel free to make edits.

Of course, this could all wait until everything else is completed.

-Roy

From: Steven Koonin <steven.koonin@gmail.com>

Sent: Tuesday, May 6, 2025 9:02 PM

To: John Christy <climateman60@gmail.com>

Cc: Ross McKittrick <ross.mckittrick@gmail.com>; Judith Curry <curry.judith@gmail.com>; Roy W. Spencer <roywspencer@hotmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>

Subject: Re: Ch 8 Extreme weather

I was expecting to read/comment/edit Chapter 8 tomorrow (Wednesday), so I'll use this version. Roy, if you beat me to a summary, that's fine, else I'll take it on.

John, do decouple for at least a few days. I've made the mistake of not doing so on a few vacations, with great regrets afterward.

Steven Koonin

On May 6, 2025, at 21:53, John Christy <climateman60@gmail.com> wrote:

All

Here is a cleaned up version of chapter 8 which you will likely not see until 7 May, so that is the date.

My preference is for someone to read the thing and write the summary (8.4) based upon what a fresh set of eyes would conclude. Steve? Roy?

Ross. The panel charts of the individual station precipitation take up a lot of real estate and I think the value per acre is low. Since you calculated 3 statistics for each station, could you craft a bar chart or something to show that result? You would then have 9 charts, one for each of the 3 statistics and one each of the three regions. The nine charts may be panelized and fit on one plot. I know for us it's important for people to see the actual data (which is why I had those colored bar charts - now monochromatic), but it may be overkill for this document.

As to one of the statistics, I believe 3-day totals will be more meaningful and accurate than 1-day totals. I could send you a file of the heaviest 3-day total for each station and each year and you can do the analysis from there.

I especially like the way you parsed the Sidebar and I hope smart people will finally understand that when dealing with climate, our sample is pathetically small from which to draw hard conclusions.

I also enjoyed the added words on LTP. In fact do you have a few sentences that expand that a little to talk about the erratic nature of precipitation (spatial and temporal) in fancy statistical terms which means finding statistical significance in such a variable is a tough job?

I redid the number-of-event bar charts - all one color now.

I reran the Heatwave results to use 6-day periods as did NCA5. NCA5 was slick though. By choosing 1961-90 their background climatology was cold relative to decades before and since, so that results outside of those 30 years would produce a lot of days that exceed the percentile threshold. Then in the urban heatwave website, they started in 1960, assuring a result that more temps would exceed the threshold in post-1990 years.

That's all I've got.

Aloha

John C.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
climateman60@gmail.com

<8 Extreme weather.JRC.May07.docx>

On May 6, 2025, at 5:25 PM, John Christy
<climateman60@gmail.com> wrote:

Steve

As Ross notes, the precipitation section is simply an update of our 2019 paper. The daily temperature work from the supplemented USHCN records is in a paper under review (but I suspect will have difficulty being accepted). The data are from the official USHCN site with my supplements adding about 10

percent to cover the missing data. There are about 41 million temperatures here, so I added about 4 million. Thus the results are dominated by publically-available data for others to check. If I get the go-ahead for publication, I can put the complete datafiles on a server for anyone to use.

John C.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
climateman60@gmail.com

On May 6, 2025, at 3:48 PM, Ross McKittrick
<ross.mckittrick@gmail.com> wrote:

The underlying analysis is all from John's and my Journal of Hydrology paper for which the code is already online. John updated and expanded the data sets and I ran them through the same code.

On Tue, May 6, 2025 at 4:41 PM Steven Koonin
<steven.koonin@gmail.com> wrote:

A thought about the analysis of long-term CONUS data, which as John knows I like very much:

If some (most?) of this work is as-yet unpublished in a peer-reviewed journal, I'd think you've got to make the expanded and in-filled database (and analysis code?) publicly accessible so that the work can be checked. Are you prepared to do that (at least for the "final", if not the "draft")?

SEK

From: Ross McKittrick <ross.mckittrick@gmail.com>
Sent: Tuesday, May 6, 2025 1:05 PM
To: John Christy <climateman60@gmail.com>
Cc: Judith Curry <curry.judith@gmail.com>; Roy W. Spencer <roywspencer@hotmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>; Steven Koonin <steven.koonin@googlemail.com>
Subject: Re: Ch 8 Extreme weather

Here's another edition of Ch 8 on extremes taking Judy's and John's points into account. The IPCC/NCA review is ported to an Appendix. I added a paragraph about LTP to the intro. I've incorporated the NE data. The bulk of the chapter is John's US temperature and precip data analysis with some additional material on wildfires, drought and TCs. For the US temperature extremes I moved the range figure to come just after the hot/cold extremes count because I think they both make a coherent point namely that the US becoming less extreme because heat events are rising more slowly than cold events are warming. There will still need to be an overall chapter summary but I'm going to move on to other chapters now. I'll put this in the Dropbox.

On Tue, May 6, 2025 at 12:12 PM John Christy <climateman60@gmail.com> wrote:

All

We can fill in without much trouble the change, or lack thereof, of “high impact” weather events (mainly wind and flooding like hurricanes, tornadoes etc) in the CONUS Extreme chapter. The temp and precip metrics are important because they are just long enough to essentially tell us Mother Nature has a mind of her own.

1. I'll look at Ross's version of 8 soon, but my hope was that Ross would translate the statistical remarks into the correct language(eg are their more precise words that chaotic, episodic, stochastic, etc).

2. We have analyses of the CONUS with more complete datasets than the NCA used (recall NCA analyses depended essentially on a small group at NCEI using datasets that (a) were not very consistent in time, (b) could promote alarm and (c) already easy for them to get to. Our datasets have literally hundreds of thousands of manually keyed-in observations for temporal consistency. In other words, this lets people know we can address these issues from soup to nuts - we're not armchair climate scientists ... we can reproduce what they did, but make the analysis more comprehensive to address the questions.

John C.

Sent from my iPhone

On May 6, 2025, at 4:14 AM,
Ross McKitrick

<ross.mckitrick@gmail.com>
wrote:

Just read your attribution chapter. I hadn't picked up on the gap between IPCC Ch 11 vs Ch 12 language but i see your point that rather than promoting one set of attribution findings

we should explain that even within the same AR different authors assessed things differently. One option is to leave Ch 6 where it is but reverse the order of Ch 7 and 8 while retitling the latter as you suggest. That way, having established the extreme weather types for which there are no detectable trends it will more naturally follow that they won't be discussed in the attribution chapter.

On Tue, May 6, 2025 at 9:45 AM Judith Curry <curry.judith@gmail.com> wrote:

Ok, but the summary table (12.12 from AR6) is inconsistent with conclusions in AR6 ch 11 (I point this out in section 6.4 of my attribution chapter).

In my mind, the main point is disagreement and ambiguity I would suggest chapter 8 going before chapter 6, retitling it as US Weather and Climate Extremes, and make it more of a data chapter, not an attribution chapter (I would put table 12.12 in the attribution chapter if you want to include the actual table)

On Tue, May 6, 2025 at 6:39 AM Ross McKittrick <ross.mckitrick@gmail.com> wrote:

I like john's material too which is why I included it and am working on the extended regional analyses. But on this topic people are heavily primed to believe that extreme weather of all kinds is getting worse due to climate change. The assertion shows up everywhere climate change is discussed including in academic papers. I think it is very valuable to show people that neither the IPCC nor the NCA support such this view. We should at least lead off with the summary table. The library of quotes can go to an appendix but I have found in my public speaking that they have considerable persuasive force for most people. We also need to address floods, droughts, hurricane landfalls, tornadoes etc. I don't see any reason to delete all that material.

On Tue, May 6, 2025 at 9:22 AM Judith Curry <curry.judith@gmail.com> wrote:

I actually liked John's chapter. I would have retitled it "US temperature and rainfall extremes"

I think this is more relevant than a complete rehash of everything the last 3 IPCC reports have stated for every conceivable severe weather event.

John's version meshes very well with my version of

chapter 6. Read especially section 6.4 of my chapter. I note a discrepancy between chapters 11 and 12 in terms of detecting and attributing extreme events. This is the main point in my opinion, there is ambiguity in all this. Lets focus on pointing out the problems/challenges, and topics that are particularly relevant for the US

On Mon, May 5, 2025 at 7:47 PM Ross McKittrick <ross.mckittrick@gmail.com> wrote:

I have wrangled the extreme weather chapter into something I hope flows better and is more readable. I adopted Judy's editorial changes and then the new changes I made are in red. I added some new Figures showing results on PC and SE data and will add the NE chart when I get the data. I also made some labeling suggestions including for the 3 rainfall charts that are hard to understand. Section summaries and an overall summary are still needed.

Ross

--

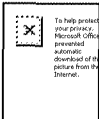
<~WRD0765.jpg>

Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

--

<~WRD0765.jpg>

Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>



Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

From: Roy Spencer <roywspencer@hotmail.com>
Sent: Wednesday, May 7, 2025 5:13 PM
To: Ross McKittrick; Steven Koonin
Cc: Travis Fisher; Judith Curry; John Christy
Subject: RE: May 8 meeting

Me too.

Sent from my Verizon, Samsung Galaxy smartphone

----- Original message -----

From: Ross McKittrick <ross.mckittrick@gmail.com>
Date: 5/7/25 4:12 PM (GMT-06:00)
To: Steven Koonin <steven.koonin@gmail.com>
Cc: Travis Fisher <travis.scott.fisher@gmail.com>, Roy Spencer <roywspencer@hotmail.com>, Judith Curry <curry.judith@gmail.com>, John Christy <climateman60@gmail.com>
Subject: Re: May 8 meeting

Me too

On Wed, May 7, 2025 at 4:56 PM Steven Koonin <steven.koonin@gmail.com> wrote:
Works for me.

Steven E. Koonin

On May 7, 2025, at 16:49, Travis Fisher <travis.scott.fisher@gmail.com> wrote:

Hi all,

Sorry to give you a moving target, but the latest word is that the Secretary's schedule isn't clear until 4 p.m. ET tomorrow. We should have 30 minutes with him (4 p.m. to 4:30 p.m. ET), and I'll work to set up an MS Teams video conference or a phone line you all can call into.

Best,
Travis

On Wed, May 7, 2025 at 12:39 PM Roy Spencer <roywspencer@hotmail.com> wrote:
For your entertainment and viewing pleasure, here's my blog response, which links to this morning's Politico article.

-Roy

<https://www.drroyspencer.com/2025/05/politicos-hit-piece-on-me-and-energy-secretary-wright/>

From: Travis Fisher <travis.scott.fisher@gmail.com>
Sent: Wednesday, May 7, 2025 10:37 AM
To: Judith Curry <curry.judith@gmail.com>
Cc: Roy Spencer <roywspencer@hotmail.com>; Steven Koonin <steven.koonin@gmail.com>; John Christy <climateman60@gmail.com>; Ross McKittrick <ross.mckittrick@gmail.com>
Subject: Re: Glossary

I'd be happy to take on the next version of the glossary. You don't need a PhD to do that, and I'm happy to take anything like that off your hands!

On Wed, May 7, 2025 at 10:31 AM Judith Curry <curry.judith@gmail.com> wrote:
thx for doing this. There are alot of acronyms used in the various chapters that should be included also

On Wed, May 7, 2025 at 3:45 AM Roy Spencer <roywspencer@hotmail.com> wrote:
Attached is my first cut at a glossary, 64 terms so far based upon my reading of the chapters.

I've omitted obvious things like EPA, CO2, NOAA, NASA...

I'm sure I missed a few terms, and feel free to make edits.

Of course, this could all wait until everything else is completed.

-Roy

From: Steven Koonin <steven.koonin@gmail.com>
Sent: Tuesday, May 6, 2025 9:02 PM
To: John Christy <climateman60@gmail.com>
Cc: Ross McKittrick <ross.mckittrick@gmail.com>; Judith Curry <curry.judith@gmail.com>; Roy W. Spencer <roywspencer@hotmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>
Subject: Re: Ch 8 Extreme weather

I was expecting to read/comment/edit Chapter 8 tomorrow (Wednesday), so I'll use this version. Roy, if you beat me to a summary, that's fine, else I'll take it on.

John, do decouple for at least a few days. I've made the mistake of not doing so on a few vacations, with great regrets afterward.

Steven Koonin

On May 6, 2025, at 21:53, John Christy <climateman60@gmail.com> wrote:

All

Here is a cleaned up version of chapter 8 which you will likely not see until 7 May, so that is the date.

My preference is for someone to read the thing and write the summary (8.4) based upon what a fresh set of eyes would conclude. Steve? Roy?

Ross. The panel charts of the individual station precipitation take up a lot of real estate and I think the value per acre is low. Since you calculated 3 statistics for each station, could you craft a bar chart or something to show that result? You would then have 9 charts, one for each of the 3 statistics and one each of the three regions. The nine charts may be panelized and fit on one plot. I know for us it's important for people to see the actual data (which is why I had those colored bar charts - now monochromatic), but it may be overkill for this document.

As to one of the statistics, I believe 3-day totals will be more meaningful and accurate than 1-day totals. I could send you a file of the heaviest 3-day total for each station and each year and you can do the analysis from there.

I especially like the way you parsed the Sidebar and I hope smart people will finally understand that when dealing with climate, our sample is pathetically small from which to draw hard conclusions.

I also enjoyed the added words on LTP. In fact do you have a few sentences that expand that a little to talk about the erratic nature of precipitation (spatial and temporal) in fancy statistical terms which means finding statistical significance in such a variable is a tough job?

I redid the number-of-event bar charts - all one color now.

I reran the Heatwave results to use 6-day periods as did NCA5. NCA5 was slick though. By choosing 1961-90 their background climatology was cold relative to decades before and since, so that results outside of those 30 years would produce a lot of days that exceed the percentile threshold. Then in the urban heatwave website, they started in 1960, assuring a result that more temps would exceed the threshold in post-1990 years.

That's all I've got.

Aloha

John C.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
climateman60@gmail.com

On May 6, 2025, at 5:25 PM, John Christy
<climateman60@gmail.com> wrote:

Steve

As Ross notes, the precipitation section is simply an update of our 2019 paper. The daily temperature work from the supplemented USHCN records is in a paper under review (but I suspect will have difficulty being accepted). The data are from the official USHCN site with my supplements adding about 10 percent to cover the missing data. There are about 41 million temperatures here, so I added about 4 million. Thus the results are dominated by publically-available data for others to check. If I get the go-ahead for publication, I can put the complete datafiles on a server for anyone to use.

John C.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
climateman60@gmail.com

On May 6, 2025, at 3:48 PM, Ross McKittrick
<ross.mckittrick@gmail.com> wrote:

The underlying analysis is all from John's and my Journal of Hydrology paper for which the code is already online. John updated and expanded the data sets and I ran them through the same code.

On Tue, May 6, 2025 at 4:41 PM Steven
Koonin <steven.koonin@gmail.com> wrote:

A thought about the analysis of long-term CONUS data, which as John knows I like very much:

If some (most?) of this work is as-yet unpublished in a peer-reviewed journal, I'd think you've got to make the expanded and in-filled database (and analysis code?) publicly accessible so that the work can be checked. Are you prepared to do that (at least for the "final", if not the "draft")?

SEK

From: Ross McKittrick <ross.mckittrick@gmail.com>
Sent: Tuesday, May 6, 2025 1:05 PM
To: John Christy <climateman60@gmail.com>
Cc: Judith Curry <curry.judith@gmail.com>; Roy W. Spencer <roywspencer@hotmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>; Steven Koonin <steven.koonin@googlemail.com>
Subject: Re: Ch 8 Extreme weather

Here's another edition of Ch 8 on extremes taking Judy's and John's points into account. The IPCC/NCA review is ported to an Appendix. I added a paragraph about LTP to the intro. I've incorporated the NE data. The bulk of the chapter is John's US temperature and precip data analysis with some additional material on wildfires, drought and TCs. For the US temperature extremes I moved the range figure to come just after the hot/cold extremes count because I think they both make a coherent point namely that the US becoming less extreme because heat events are rising more slowly than cold events are warming. There will still need to be an overall chapter summary but I'm going to move on to other chapters now. I'll put this in the Dropbox.

On Tue, May 6, 2025 at 12:12 PM John Christy <climateman60@gmail.com> wrote:

All

We can fill in without much trouble the change, or lack thereof, of “high impact” weather events (mainly wind and flooding like hurricanes, tornadoes etc) in the CONUS Extreme chapter. The temp and precip metrics are important because they are just long enough to essentially tell us Mother Nature has a mind of her own.

1. I’ll look at Ross’s version of 8 soon, but my hope was that Ross would translate the statistical remarks into the correct language(eg are their more precise words that chaotic, episodic, stochastic, etc).

2. We have analyses of the CONUS with more complete datasets than the NCA used (recall NCA analyses depended essentially on a small group at NCEI using datasets that (a) were not very consistent in time, (b) could promote alarm and (c) already easy for them to get to. Our datasets have literally hundreds of thousands of manually keyed-in observations for temporal consistency. In other words, this lets people know we can address these issues from soup to nuts - we’re not armchair climate scientists ... we can reproduce what they did, but make the analysis more comprehensive to address the questions.

John C.

Sent from my iPhone

On May 6, 2025, at 4:14 AM,
Ross McKittrick

<ross.mckitrick@gmail.com>
wrote:

Just read your attribution chapter. I hadn't picked up on the gap between IPCC Ch 11 vs Ch 12 language but i see your point that rather than promoting one set of attribution findings we should explain that even within the same AR different authors assessed things differently. One option is to leave Ch 6 where it is but reverse the order of Ch 7 and 8 while retitling the latter as you suggest. That way, having established the extreme weather types for which there are no detectable trends it will more naturally follow that they won't be discussed in the attribution chapter.

On Tue, May 6, 2025 at 9:45 AM Judith Curry
<curry.judith@gmail.com>
wrote:

Ok, but the summary table (12.12 from AR6) is inconsistent with conclusions in AR6 ch 11 (I point this out in section 6.4 of my attribution chapter).

In my mind, the main point is disagreement and ambiguity I

would suggest chapter 8 going before chapter 6, retitling it as US Weather and Climate Extremes, and make it more of a data chapter, not an attribution chapter (I would put table 12.12 in the attribution chapter if you want to include the actual table)

On Tue, May 6, 2025 at 6:39 AM Ross McKittrick <ross.mckittrick@gmail.com> wrote:

I like john's material too which is why I included it and am working on the extended regional analyses. But on this topic people are heavily primed to believe that extreme weather of all kinds is getting worse due to climate change. The assertion shows up everywhere climate change is discussed including in academic papers. I think it is very valuable to show people that neither the IPCC nor the NCA support such this view. We should at least lead off with the summary table. The library of quotes can go to an appendix but I have found in my public speaking that they have considerable persuasive force for most people. We also need to address floods, droughts, hurricane landfalls, tornadoes etc. I don't see any reason to delete all that material.

On Tue, May 6, 2025 at 9:22 AM Judith Curry

<curry.judith@gmail.com>

wrote:

I actually liked John's chapter. I would have retitled it "US temperature and rainfall extremes"

I think this is more relevant than a complete rehash of everything the last 3 IPCC reports have stated for every conceivable severe weather event.

John's version meshes very well with my version of chapter 6. Read especially section 6.4 of my chapter. I note a discrepancy between chapters 11 and 12 in terms of detecting and attributing extreme events. This is the main point in my opinion, there is ambiguity in all this. Lets focus on pointing out the problems/challenges, and topics that are particularly relevant for the US

On Mon, May 5, 2025 at 7:47 PM Ross McKittrick <ross.mckitrick@gmail.com> wrote:

I have wrangled the extreme weather chapter into something I hope flows better and is more readable. I adopted Judy's editorial changes and then the new changes I made

are in red. I added some
new Figures
showing results on PC and
SE data and will add the
NE chart when I get the
data. I also made some
labeling suggestions
including for the 3 rainfall
charts that are hard to
understand. Section
summaries and an overall
summary are still needed.

Ross

--

<~WRD0765.jpg>

Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

--

<~WRD0765.jpg>

Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>



--

Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

From: Ross McKittrick <ross.mckitrick@gmail.com>
Sent: Wednesday, May 7, 2025 5:13 PM
To: Steven Koonin
Cc: Travis Fisher; Roy Spencer; Judith Curry; John Christy
Subject: Re: May 8 meeting

Me too

On Wed, May 7, 2025 at 4:56 PM Steven Koonin <steven.koonin@gmail.com> wrote:
Works for me.

Steven E. Koonin

On May 7, 2025, at 16:49, Travis Fisher <travis.scott.fisher@gmail.com> wrote:

Hi all,

Sorry to give you a moving target, but the latest word is that the Secretary's schedule isn't clear until 4 p.m. ET tomorrow. We should have 30 minutes with him (4 p.m. to 4:30 p.m. ET), and I'll work to set up an MS Teams video conference or a phone line you all can call into.

Best,
Travis

On Wed, May 7, 2025 at 12:39 PM Roy Spencer <roywspencer@hotmail.com> wrote:
For your entertainment and viewing pleasure, here's my blog response, which links to this morning's Politico article.

-Roy

<https://www.drroyspencer.com/2025/05/politicos-hit-piece-on-me-and-energy-secretary-wright/>

From: Travis Fisher <travis.scott.fisher@gmail.com>
Sent: Wednesday, May 7, 2025 10:37 AM
To: Judith Curry <curry.judith@gmail.com>
Cc: Roy Spencer <roywspencer@hotmail.com>; Steven Koonin <steven.koonin@gmail.com>; John Christy <climateman60@gmail.com>; Ross McKittrick <ross.mckitrick@gmail.com>
Subject: Re: Glossary

I'd be happy to take on the next version of the glossary. You don't need a PhD to do that, and I'm happy to take anything like that off your hands!

On Wed, May 7, 2025 at 10:31 AM Judith Curry <curry.judith@gmail.com> wrote:

thx for doing this. There are a lot of acronyms used in the various chapters that should be included also

On Wed, May 7, 2025 at 3:45 AM Roy Spencer <roywspencer@hotmail.com> wrote:
Attached is my first cut at a glossary, 64 terms so far based upon my reading of the chapters.

I've omitted obvious things like EPA, CO2, NOAA, NASA...

I'm sure I missed a few terms, and feel free to make edits.

Of course, this could all wait until everything else is completed.

-Roy

From: Steven Koonin <steven.koonin@gmail.com>

Sent: Tuesday, May 6, 2025 9:02 PM

To: John Christy <climateman60@gmail.com>

Cc: Ross McKittrick <ross.mckittrick@gmail.com>; Judith Curry <curry.judith@gmail.com>; Roy W. Spencer <roywspencer@hotmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>

Subject: Re: Ch 8 Extreme weather

I was expecting to read/comment/edit Chapter 8 tomorrow (Wednesday), so I'll use this version. Roy, if you beat me to a summary, that's fine, else I'll take it on.

John, do decouple for at least a few days. I've made the mistake of not doing so on a few vacations, with great regrets afterward.

Steven Koonin

On May 6, 2025, at 21:53, John Christy <climateman60@gmail.com> wrote:

All

Here is a cleaned up version of chapter 8 which you will likely not see until 7 May, so that is the date.

My preference is for someone to read the thing and write the summary (8.4) based upon what a fresh set of eyes would conclude. Steve? Roy?

Ross. The panel charts of the individual station precipitation take up a lot of real estate and I think the value per acre is low. Since you calculated 3 statistics for each station, could you craft a bar chart or something to show that result? You would then have 9 charts, one for each of the 3 statistics and one each of the three regions. The nine charts may be panelized and fit on one plot. I know for us it's important for people to see the actual data (which is why I had those colored bar charts - now monochromatic), but it may be overkill for this document.

As to one of the statistics, I believe 3-day totals will be more meaningful and accurate than 1-day totals. I could send you a file of the heaviest 3-day total for each station and each year and you can do the analysis from there.

I especially like the way you parsed the Sidebar and I hope smart people will finally understand that when dealing with climate, our sample is pathetically small from which to draw hard conclusions.

I also enjoyed the added words on LTP. In fact do you have a few sentences that expand that a little to talk about the erratic nature of precipitation (spatial and temporal) in fancy statistical terms which means finding statistical significance in such a variable is a tough job?

I redid the number-of-event bar charts - all one color now.

I reran the Heatwave results to use 6-day periods as did NCA5. NCA5 was slick though. By choosing 1961-90 their background climatology was cold relative to decades before and since, so that results outside of those 30 years would produce a lot of days that exceed the percentile threshold. Then in the urban heatwave website, they started in 1960, assuring a result that more temps would exceed the threshold in post-1990 years.

That's all I've got.

Aloha

John C.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
climateman60@gmail.com

<8 Extreme weather.JRC.May07.docx>

On May 6, 2025, at 5:25 PM, John Christy
<climateman60@gmail.com> wrote:

Steve

As Ross notes, the precipitation section is simply an update of our 2019 paper. The daily temperature work from the supplemented USHCN records is in a paper under review (but I suspect will have difficulty being accepted). The data are from the official USHCN site with my supplements adding

about 10 percent to cover the missing data. There are about 41 million temperatures here, so I added about 4 million. Thus the results are dominated by publically-available data for others to check. If I get the go-ahead for publication, I can put the complete datafiles on a server for anyone to use.

John C.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
climateman60@gmail.com

On May 6, 2025, at 3:48 PM, Ross McKittrick
<ross.mckittrick@gmail.com> wrote:

The underlying analysis is all from John's and my Journal of Hydrology paper for which the code is already online. John updated and expanded the data sets and I ran them through the same code.

On Tue, May 6, 2025 at 4:41 PM Steven Koonin <steven.koonin@gmail.com> wrote:

A thought about the analysis of long-term CONUS data, which as John knows I like very much:

If some (most?) of this work is as-yet unpublished in a peer-reviewed journal, I'd think you've got to make the expanded and in-filled database (and analysis code?) publicly accessible so that the work can be checked. Are you prepared to do that (at least for the "final", if not the "draft")?

SEK

From: Ross McKittrick <ross.mckittrick@gmail.com>
Sent: Tuesday, May 6, 2025 1:05 PM
To: John Christy <climateman60@gmail.com>
Cc: Judith Curry <curry.judith@gmail.com>; Roy W. Spencer <roywspencer@hotmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>; Steven Koonin <steven.koonin@googlemail.com>
Subject: Re: Ch 8 Extreme weather

Here's another edition of Ch 8 on extremes taking Judy's and John's points into account. The IPCC/NCA review is ported to an Appendix. I added a paragraph about LTP to the intro. I've incorporated the NE data. The bulk of the chapter is John's US temperature and precip data analysis with some additional material on wildfires, drought and TCs. For the US temperature extremes I moved the range figure to come just after the hot/cold extremes count because I think they both make a coherent point namely that the US becoming less extreme because heat events are rising more slowly than cold events are warming. There will still need to be an overall chapter summary but I'm going to move on to other chapters now. I'll put this in the Dropbox.

On Tue, May 6, 2025 at 12:12 PM John Christy <climateman60@gmail.com> wrote:

All

We can fill in without much trouble the change, or lack thereof, of “high impact” weather events (mainly wind and flooding like hurricanes, tornadoes etc) in the CONUS Extreme chapter. The temp and precip metrics are important because they are just long enough to essentially tell us Mother Nature has a mind of her own.

1. I'll look at Ross's version of 8 soon, but my hope was that Ross would translate the statistical remarks into the correct language(eg are their more precise words that chaotic, episodic, stochastic, etc).

2. We have analyses of the CONUS with more complete datasets than the NCA used (recall NCA analyses depended essentially on a small group at NCEI using datasets that (a) were not very consistent in time, (b) could promote alarm and (c) already easy for them to get to. Our datasets have literally hundreds of thousands of manually keyed-in observations for temporal consistency. In other words, this lets people know we can address these issues from soup to nuts - we're not armchair climate scientists ... we can reproduce what they did, but make the analysis more comprehensive to address the questions.

John C.

Sent from my iPhone

On May 6, 2025, at 4:14 AM,
Ross McKittrick

<ross.mckittrick@gmail.com>
wrote:

Just read your attribution chapter. I hadn't picked up on the gap between IPCC Ch 11 vs Ch 12 language but i see your point that rather than

promoting one set of attribution findings we should explain that even within the same AR different authors assessed things differently. One option is to leave Ch 6 where it is but reverse the order of Ch 7 and 8 while retitling the latter as you suggest. That way, having established the extreme weather types for which there are no detectable trends it will more naturally follow that they won't be discussed in the attribution chapter.

On Tue, May 6, 2025 at 9:45 AM Judith Curry <curry.judith@gmail.com> wrote:

Ok, but the summary table (12.12 from AR6) is inconsistent with conclusions in AR6 ch 11 (I point this out in section 6.4 of my attribution chapter).

In my mind, the main point is disagreement and ambiguity I would suggest chapter 8 going before chapter 6, retitling it as US Weather and Climate Extremes, and make it more of a data chapter, not an attribution chapter (I would put table 12.12 in the attribution chapter if you want to include the actual table)

On Tue, May 6, 2025 at 6:39 AM Ross McKittrick

<ross.mckitrick@gmail.com>

wrote:

I like john's material too which is why I included it and am working on the extended regional analyses. But on this topic people are heavily primed to believe that extreme weather of all kinds is getting worse due to climate change. The assertion shows up everywhere climate change is discussed including in academic papers. I think it is very valuable to show people that neither the IPCC nor the NCA support such this view. We should at least lead off with the summary table. The library of quotes can go to an appendix but I have found in my public speaking that they have considerable persuasive force for most people. We also need to address floods, droughts, hurricane landfalls, tornadoes etc. I don't see any reason to delete all that material.

On Tue, May 6, 2025 at

9:22 AM Judith Curry

<curry.judith@gmail.com>

wrote:

I actually liked John's chapter. I would have retitled it "US temperature and rainfall extremes"

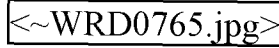
I think this is more relevant than a complete rehash of everything the last 3 IPCC reports have stated for every conceivable severe weather event.

John's version meshes very well with my version of chapter 6. Read especially section 6.4 of my chapter. I note a discrepancy between chapters 11 and 12 in terms of detecting and attributing extreme events. This is the main point in my opinion, there is ambiguity in all this. Lets focus on pointing out the problems/challenges, and topics that are particularly relevant for the US

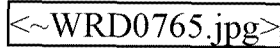
On Mon, May 5, 2025 at 7:47 PM Ross McKittrick <ross.mckitrick@gmail.com> wrote:

I have wrangled the extreme weather chapter into something I hope flows better and is more readable. I adopted Judy's editorial changes and then the new changes I made are in red. I added some new Figures showing results on PC and SE data and will add the NE chart when I get the data. I also made some labeling suggestions including for the 3 rainfall charts that are hard to understand. Section summaries and an overall summary are still needed.

Ross

--


Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

--


Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>



Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

From: Steven Koonin <steven.koonin@gmail.com>
Sent: Wednesday, May 7, 2025 4:56 PM
To: Travis Fisher
Cc: Roy Spencer; Judith Curry; John Christy; Ross McKittrick
Subject: Re: May 8 meeting

Works for me.

Steven E. Koonin

On May 7, 2025, at 16:49, Travis Fisher <travis.scott.fisher@gmail.com> wrote:

Hi all,

Sorry to give you a moving target, but the latest word is that the Secretary's schedule isn't clear until 4 p.m. ET tomorrow. We should have 30 minutes with him (4 p.m. to 4:30 p.m. ET), and I'll work to set up an MS Teams video conference or a phone line you all can call into.

Best,
Travis

On Wed, May 7, 2025 at 12:39 PM Roy Spencer <roywspencer@hotmail.com> wrote:
For your entertainment and viewing pleasure, here's my blog response, which links to this morning's Politico article.

-Roy

<https://www.drroyspencer.com/2025/05/politicos-hit-piece-on-me-and-energy-secretary-wright/>

From: Travis Fisher <travis.scott.fisher@gmail.com>
Sent: Wednesday, May 7, 2025 10:37 AM
To: Judith Curry <curry.judith@gmail.com>
Cc: Roy Spencer <roywspencer@hotmail.com>; Steven Koonin <steven.koonin@gmail.com>; John Christy <climateman60@gmail.com>; Ross McKittrick <ross.mckittrick@gmail.com>
Subject: Re: Glossary

I'd be happy to take on the next version of the glossary. You don't need a PhD to do that, and I'm happy to take anything like that off your hands!

On Wed, May 7, 2025 at 10:31 AM Judith Curry <curry.judith@gmail.com> wrote:
thx for doing this. There are alot of acronyms used in the various chapters that should be included also

On Wed, May 7, 2025 at 3:45 AM Roy Spencer <roywspencer@hotmail.com> wrote:
Attached is my first cut at a glossary, 64 terms so far based upon my reading of the chapters.

I've omitted obvious things like EPA, CO2, NOAA, NASA...

I'm sure I missed a few terms, and feel free to make edits.

Of course, this could all wait until everything else is completed.

-Roy

From: Steven Koonin <steven.koonin@gmail.com>

Sent: Tuesday, May 6, 2025 9:02 PM

To: John Christy <climateman60@gmail.com>

Cc: Ross McKittrick <ross.mckittrick@gmail.com>; Judith Curry <curry.judith@gmail.com>; Roy W. Spencer <roywspencer@hotmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>

Subject: Re: Ch 8 Extreme weather

I was expecting to read/comment/edit Chapter 8 tomorrow (Wednesday), so I'll use this version. Roy, if you beat me to a summary, that's fine, else I'll take it on.

John, do decouple for at least a few days. I've made the mistake of not doing so on a few vacations, with great regrets afterward.

Steven Koonin

On May 6, 2025, at 21:53, John Christy <climateman60@gmail.com> wrote:

All

Here is a cleaned up version of chapter 8 which you will likely not see until 7 May, so that is the date.

My preference is for someone to read the thing and write the summary (8.4) based upon what a fresh set of eyes would conclude. Steve? Roy?

Ross. The panel charts of the individual station precipitation take up a lot of real estate and I think the value per acre is low. Since you calculated 3 statistics for each station, could you craft a bar chart or something to show that result? You would then have 9 charts, one for each of the 3 statistics and one each of the three regions. The nine charts may be panelized and fit on one plot. I know for us it's important for people to see the actual data (which is why I had those colored bar charts - now monochromatic), but it may be overkill for this document.

As to one of the statistics, I believe 3-day totals will be more meaningful and accurate than 1-day totals. I could send you a file of the heaviest 3-day total for each station and each year and you can do the analysis from there.

I especially like the way you parsed the Sidebar and I hope smart people will finally understand that when dealing with climate, our sample is pathetically small from which to draw hard conclusions.

I also enjoyed the added words on LTP. In fact do you have a few sentences that expand that a little to talk about the erratic nature of precipitation (spatial and temporal) in fancy statistical terms which means finding statistical significance in such a variable is a tough job?

I redid the number-of-event bar charts - all one color now.

I reran the Heatwave results to use 6-day periods as did NCA5. NCA5 was slick though. By choosing 1961-90 their background climatology was cold relative to decades before and since, so that results outside of those 30 years would produce a lot of days that exceed the percentile threshold. Then in the urban heatwave website, they started in 1960, assuring a result that more temps would exceed the threshold in post-1990 years.

That's all I've got.

Aloha

John C.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
climateman60@gmail.com

<8 Extreme weather.JRC.May07.docx>

On May 6, 2025, at 5:25 PM, John Christy
<climateman60@gmail.com> wrote:

Steve

As Ross notes, the precipitation section is simply an update of our 2019 paper. The daily temperature work from the supplemented USHCN records is in a paper under review (but I suspect will have difficulty being accepted). The data are from the official USHCN site with my supplements adding about 10 percent to cover the missing data. There are about 41 million temperatures here, so I added about 4 million. Thus the results are dominated by publically-available data for others to

check. If I get the go-ahead for publication, I can put the complete datafiles on a server for anyone to use.

John C.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
climateman60@gmail.com

On May 6, 2025, at 3:48 PM, Ross McKittrick
<ross.mckittrick@gmail.com> wrote:

The underlying analysis is all from John's and my Journal of Hydrology paper for which the code is already online. John updated and expanded the data sets and I ran them through the same code.

On Tue, May 6, 2025 at 4:41 PM Steven Koonin
<steven.koonin@gmail.com> wrote:

A thought about the analysis of long-term CONUS data, which as John knows I like very much:

If some (most?) of this work is as-yet unpublished in a peer-reviewed journal, I'd think you've got to make the expanded and in-filled database (and analysis code?) publicly accessible so that the work can be checked. Are you prepared to do that (at least for the "final", if not the "draft")?

SEK

From: Ross McKittrick <ross.mckittrick@gmail.com>
Sent: Tuesday, May 6, 2025 1:05 PM
To: John Christy <climateman60@gmail.com>

Cc: Judith Curry <curry.judith@gmail.com>; Roy W. Spencer <roywspencer@hotmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>; Steven Koonin <steven.koonin@googlemail.com>
Subject: Re: Ch 8 Extreme weather

Here's another edition of Ch 8 on extremes taking Judy's and John's points into account. The IPCC/NCA review is ported to an Appendix. I added a paragraph about LTP to the intro. I've incorporated the NE data. The bulk of the chapter is John's US temperature and precip data analysis with some additional material on wildfires, drought and TCs. For the US temperature extremes I moved the range figure to come just after the hot/cold extremes count because I think they both make a coherent point namely that the US becoming less extreme because heat events are rising more slowly than cold events are warming. There will still need to be an overall chapter summary but I'm going to move on to other chapters now. I'll put this in the Dropbox.

On Tue, May 6, 2025 at 12:12 PM John Christy <climateman60@gmail.com> wrote:

All

We can fill in without much trouble the change, or lack thereof, of “high impact” weather events (mainly wind and flooding like hurricanes, tornadoes etc) in the CONUS Extreme chapter. The temp and precip metrics are important because they are just long enough to essentially tell us Mother Nature has a mind of her own.

1. I'll look at Ross's version of 8 soon, but my hope was that Ross would translate the statistical remarks into the correct language(eg

are their more precise words that chaotic, episodic, stochastic, etc).

2. We have analyses of the CONUS with more complete datasets than the NCA used (recall NCA analyses depended essentially on a small group at NCEI using datasets that (a) were not very consistent in time, (b) could promote alarm and (c) already easy for them to get to. Our datasets have literally hundreds of thousands of manually keyed-in observations for temporal consistency. In other words, this lets people know we can address these issues from soup to nuts - we're not armchair climate scientists ... we can reproduce what they did, but make the analysis more comprehensive to address the questions.

John C.

Sent from my iPhone

On May 6, 2025, at 4:14 AM,
Ross McKittrick

<ross.mckittrick@gmail.com>
wrote:

Just read your attribution chapter. I hadn't picked up on the gap between IPCC Ch 11 vs Ch 12 language but i see your point that rather than promoting one set of attribution findings we should explain that even within the same AR different authors assessed things

differently. One option is to leave Ch 6 where it is but reverse the order of Ch 7 and 8 while retitling the latter as you suggest. That way, having established the extreme weather types for which there are no detectable trends it will more naturally follow that they won't be discussed in the attribution chapter.

On Tue, May 6, 2025 at 9:45 AM Judith Curry
<curry.judith@gmail.com>
wrote:

Ok, but the summary table (12.12 from AR6) is inconsistent with conclusions in AR6 ch 11 (I point this out in section 6.4 of my attribution chapter).

In my mind, the main point is disagreement and ambiguity I would suggest chapter 8 going before chapter 6, retitling it as US Weather and Climate Extremes, and make it more of a data chapter, not an attribution chapter (I would put table 12.12 in the attribution chapter if you want to include the actual table)

On Tue, May 6, 2025 at 6:39 AM Ross McKittrick
<ross.mckittrick@gmail.com>
wrote:

I like john's material too which is why I included it and

am working on the extended regional analyses. But on this topic people are heavily primed to believe that extreme weather of all kinds is getting worse due to climate change. The assertion shows up everywhere climate change is discussed including in academic papers. I think it is very valuable to show people that neither the IPCC nor the NCA support such this view. We should at least lead off with the summary table. The library of quotes can go to an appendix but I have found in my public speaking that they have considerable persuasive force for most people. We also need to address floods, droughts, hurricane landfalls, tornadoes etc. I don't see any reason to delete all that material.

On Tue, May 6, 2025 at 9:22 AM Judith Curry <curry.judith@gmail.com> wrote:

I actually liked John's chapter. I would have retitled it "US temperature and rainfall extremes"

I think this is more relevant than a complete rehash of everything the last 3 IPCC reports have stated for every conceivable severe weather event.

John's version meshes very well with my version of chapter 6. Read especially section 6.4 of my chapter. I

note a discrepancy between chapters 11 and 12 in terms of detecting and attributing extreme events. This is the main point in my opinion, there is ambiguity in all this. Lets focus on pointing out the problems/challenges, and topics that are particularly relevant for the US

On Mon, May 5, 2025 at 7:47 PM Ross McKittrick <ross.mckittrick@gmail.com> wrote:

I have wrangled the extreme weather chapter into something I hope flows better and is more readable. I adopted Judy's editorial changes and then the new changes I made are in red. I added some new Figures showing results on PC and SE data and will add the NE chart when I get the data. I also made some labeling suggestions including for the 3 rainfall charts that are hard to understand. Section summaries and an overall summary are still needed.

Ross

--

<~WRD0765.jpg>

Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

--

<~WRD0765.jpg>

Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

--



Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

From: Travis Fisher <travis.scott.fisher@gmail.com>
Sent: Wednesday, May 7, 2025 4:50 PM
To: Roy Spencer
Cc: Judith Curry; Steven Koonin; John Christy; Ross McKittrick
Subject: May 8 meeting

Hi all,

Sorry to give you a moving target, but the latest word is that the Secretary's schedule isn't clear until 4 p.m. ET tomorrow. We should have 30 minutes with him (4 p.m. to 4:30 p.m. ET), and I'll work to set up an MS Teams video conference or a phone line you all can call into.

Best,
Travis

On Wed, May 7, 2025 at 12:39 PM Roy Spencer <roywspencer@hotmail.com> wrote:
For your entertainment and viewing pleasure, here's my blog response, which links to this morning's Politico article.

-Roy

<https://www.drroyspencer.com/2025/05/politicos-hit-piece-on-me-and-energy-secretary-wright/>

From: Travis Fisher <travis.scott.fisher@gmail.com>
Sent: Wednesday, May 7, 2025 10:37 AM
To: Judith Curry <curry.judith@gmail.com>
Cc: Roy Spencer <roywspencer@hotmail.com>; Steven Koonin <steven.koonin@gmail.com>; John Christy <climateman60@gmail.com>; Ross McKittrick <ross.mckittrick@gmail.com>
Subject: Re: Glossary

I'd be happy to take on the next version of the glossary. You don't need a PhD to do that, and I'm happy to take anything like that off your hands!

On Wed, May 7, 2025 at 10:31 AM Judith Curry <curry.judith@gmail.com> wrote:
thx for doing this. There are alot of acronyms used in the various chapters that should be included also

On Wed, May 7, 2025 at 3:45 AM Roy Spencer <roywspencer@hotmail.com> wrote:
Attached is my first cut at a glossary, 64 terms so far based upon my reading of the chapters.

I've omitted obvious things like EPA, CO2, NOAA, NASA...

I'm sure I missed a few terms, and feel free to make edits.

Of course, this could all wait until everything else is completed.

-Roy

From: Steven Koonin <steven.koonin@gmail.com>

Sent: Tuesday, May 6, 2025 9:02 PM

To: John Christy <climateman60@gmail.com>

Cc: Ross McKittrick <ross.mckittrick@gmail.com>; Judith Curry <curry.judith@gmail.com>; Roy W. Spencer <roywspencer@hotmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>

Subject: Re: Ch 8 Extreme weather

I was expecting to read/comment/edit Chapter 8 tomorrow (Wednesday), so I'll use this version. Roy, if you beat me to a summary, that's fine, else I'll take it on.

John, do decouple for at least a few days. I've made the mistake of not doing so on a few vacations, with great regrets afterward.

Steven Koonin

On May 6, 2025, at 21:53, John Christy <climateman60@gmail.com> wrote:

All

Here is a cleaned up version of chapter 8 which you will likely not see until 7 May, so that is the date.

My preference is for someone to read the thing and write the summary (8.4) based upon what a fresh set of eyes would conclude. Steve? Roy?

Ross. The panel charts of the individual station precipitation take up a lot of real estate and I think the value per acre is low. Since you calculated 3 statistics for each station, could you craft a bar chart or something to show that result? You would then have 9 charts, one for each of the 3 statistics and one each of the three regions. The nine charts may be panelized and fit on one plot. I know for us it's important for people to see the actual data (which is why I had those colored bar charts - now monochromatic), but it may be overkill for this document.

As to one of the statistics, I believe 3-day totals will be more meaningful and accurate than 1-day totals. I could send you a file of the heaviest 3-day total for each station and each year and you can do the analysis from there.

I especially like the way you parsed the Sidebar and I hope smart people will finally understand that when dealing with climate, our sample is pathetically small from which to draw hard conclusions.

I also enjoyed the added words on LTP. In fact do you have a few sentences that expand that a little to talk about the erratic nature of precipitation (spatial and temporal) in fancy statistical terms which means finding statistical significance in such a variable is a tough job?

I redid the number-of-event bar charts - all one color now.

I reran the Heatwave results to use 6-day periods as did NCA5. NCA5 was slick though. By choosing 1961-90 their background climatology was cold relative to decades before and since, so that results outside of those 30 years would produce a lot of days that exceed the percentile

threshold. Then in the urban heatwave website, they started in 1960, assuring a result that more temps would exceed the threshold in post-1990 years.

That's all I've got.

Aloha

John C.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
climateman60@gmail.com

<8 Extreme weather.JRC.May07.docx>

On May 6, 2025, at 5:25 PM, John Christy <climateman60@gmail.com>
wrote:

Steve

As Ross notes, the precipitation section is simply an update of our 2019 paper. The daily temperature work from the supplemented USHCN records is in a paper under review (but I suspect will have difficulty being accepted). The data are from the official USHCN site with my supplements adding about 10 percent to cover the missing data. There are about 41 million temperatures here, so I added about 4 million. Thus the results are dominated by publically-available data for others to check. If I get the go-ahead for publication, I can put the complete datafiles on a server for anyone to use.

John C.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
climateman60@gmail.com

On May 6, 2025, at 3:48 PM, Ross McKitrick
<ross.mckitrick@gmail.com> wrote:

The underlying analysis is all from John's and my Journal of Hydrology paper for which the code is already online. John updated and expanded the data sets and I ran them through the same code.

On Tue, May 6, 2025 at 4:41 PM Steven Koonin
<steven.koonin@gmail.com> wrote:

A thought about the analysis of long-term CONUS data, which as John knows I like very much:

If some (most?) of this work is as-yet unpublished in a peer-reviewed journal, I'd think you've got to make the expanded and in-filled database (and analysis code?) publicly accessible so that the work can be checked. Are you prepared to do that (at least for the "final", if not the "draft")?

SEK

From: Ross McKitrick <ross.mckitrick@gmail.com>
Sent: Tuesday, May 6, 2025 1:05 PM
To: John Christy <climateman60@gmail.com>
Cc: Judith Curry <curry.judith@gmail.com>; Roy W. Spencer <roywspencer@hotmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>; Steven Koonin <steven.koonin@googlemail.com>
Subject: Re: Ch 8 Extreme weather

Here's another edition of Ch 8 on extremes taking Judy's and John's points into account. The IPCC/NCA review is ported to an Appendix. I added a paragraph about LTP to the intro. I've incorporated the NE data. The bulk of the chapter is John's US temperature and precip data analysis with some additional material on wildfires, drought and TCs. For the US temperature extremes I moved the range figure to come just after the hot/cold extremes count because I think they both make a coherent point namely that the US becoming less extreme because heat events are rising more slowly than cold events are warming. There will still need to be an overall

chapter summary but I'm going to move on to other chapters now. I'll put this in the Dropbox.

On Tue, May 6, 2025 at 12:12 PM John Christy
<climateman60@gmail.com> wrote:

All

We can fill in without much trouble the change, or lack thereof, of “high impact” weather events (mainly wind and flooding like hurricanes, tornadoes etc) in the CONUS Extreme chapter. The temp and precip metrics are important because they are just long enough to essentially tell us Mother Nature has a mind of her own.

1. I'll look at Ross's version of 8 soon, but my hope was that Ross would translate the statistical remarks into the correct language(eg are their more precise words that chaotic, episodic, stochastic, etc).

2. We have analyses of the CONUS with more complete datasets than the NCA used (recall NCA analyses depended essentially on a small group at NCEI using datasets that (a) were not very consistent in time, (b) could promote alarm and (c) already easy for them to get to. Our datasets have literally hundreds of thousands of manually keyed-in observations for temporal consistency. In other words, this lets people know we can address these issues from soup to nuts - we're not armchair climate scientists ... we can reproduce what they did, but make the analysis more comprehensive to address the questions.

John C.

Sent from my iPhone

On May 6, 2025, at 4:14 AM, Ross McKittrick

<ross.mckittrick@gmail.com> wrote:

Just read your attribution chapter. I hadn't picked up on the gap between IPCC Ch 11 vs Ch 12 language but i see your point that rather than promoting one set of attribution findings we should explain that even within the same AR different authors assessed things differently. One option is to leave Ch 6 where it is but reverse the order of Ch 7 and 8 while retitling the latter as you suggest. That way, having established the extreme weather types for which there are no detectable trends it will more naturally follow that they won't be discussed in the attribution chapter.

On Tue, May 6, 2025 at 9:45 AM Judith Curry
<curry.judith@gmail.com> wrote:

Ok, but the summary table (12.12 from AR6) is inconsistent with conclusions in AR6 ch 11 (I point this out in section 6.4 of my attribution chapter).

In my mind, the main point is disagreement and ambiguity I would suggest chapter 8 going before chapter 6, retitling it as US Weather and Climate Extremes, and make it more of a data chapter, not an attribution chapter (I would put table 12.12 in the attribution chapter if you want to include the actual table)

On Tue, May 6, 2025 at 6:39 AM Ross McKittrick <ross.mckittrick@gmail.com> wrote:

I like John's material too which is why I included it and am working on the extended regional analyses. But on this topic people are heavily primed to believe that extreme weather of all kinds is getting worse due to climate change. The assertion shows up everywhere climate change is discussed including in academic papers. I think it is very valuable to show people that neither the IPCC nor the NCA support such this view. We should at least lead off with the summary table. The library of quotes can go to an appendix but I have found in my public speaking that they have considerable persuasive force for most people. We also need to address floods, droughts, hurricane landfalls, tornadoes etc. I don't see any reason to delete all that material.

On Tue, May 6, 2025 at 9:22 AM Judith Curry <curry.judith@gmail.com> wrote:

I actually liked John's chapter. I would have retitled it "US temperature and rainfall extremes"

I think this is more relevant than a complete rehash of everything the last 3 IPCC reports have stated for every conceivable severe weather event.

John's version meshes very well with my version of chapter 6. Read especially section 6.4 of my chapter. I note a discrepancy between chapters 11 and 12 in terms of detecting and attributing extreme events. This is the main point in my opinion, there is ambiguity in all this. Lets focus on pointing out the problems/challenges, and topics that are particularly relevant for the US

On Mon, May 5, 2025 at 7:47 PM Ross
McKittrick <ross.mckittrick@gmail.com>
wrote:

I have wrangled the extreme weather
chapter into something I hope flows better
and is more readable. I adopted Judy's
editorial changes and then the new changes
I made are in red. I added some new
Figures showing results on PC and SE data
and will add the NE chart when I get the
data. I also made some labeling
suggestions including for the 3 rainfall
charts that are hard to understand. Section
summaries and an overall summary are
still needed.

Ross

--

<~WRD0765.jpg>

Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

--

<~WRD0765.jpg>

Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA

curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

--



To help protect
your privacy,
Outlook prevented
automatic download of this
picture from the
Internet.

Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

From: Josh Loucks (via Google Drive) <drive-shares-dm-noreply@google.com>
Sent: Wednesday, June 4, 2025 1:34 PM
To: climateman60@gmail.com
Cc: cohen.seth1994@gmail.com; curry.judith@gmail.com; ross.mckitrick@gmail.com; roywspencer@hotmail.com; steven.koonin@gmail.com
Subject: Folder shared with you: "NCA5 Review"

Josh Loucks shared a folder

Josh Loucks (loucksj14@gmail.com) has invited you to **contribute to** the following shared folder:

New Shared Folders

 NCA5 Review



Does this item look suspicious? [Block sender](#)

Google LLC, 1600 Amphitheatre Parkway, Mountain View, CA 94043, USA
You have received this email because loucksj14@gmail.com shared a file or folder located in Google Drive with you.



From: Judith Curry <curry.judith@gmail.com>
Sent: Friday, July 11, 2025 10:19 AM
To: John Christy
Cc: Steven Koonin; Ross McKittrick; Roy W. Spencer; Travis Fisher; Josh Loucks
Subject: Re: MS Copilot on NCA5

I like some of the phrasing from co-Pilot, that we could adopt. I think our NCA5 report still needs significant work

Motivated optimism with an advocacy tone
Subtle advocacy with emphasis
Attribution is implied, not dissected
Framing climate as a morality play
Dissent is invisible
Minimal discussion of observational limitations
No mention of tradeoffs

On Fri, Jul 11, 2025 at 7:08 AM John Christy <climateman60@gmail.com> wrote:
Steve

CoPilot must be influenced by sources surrounding the NCA5 when it concludes

" 🚀 **Summary Judgment**

Chapter 3 of NCA5 offers a **data-rich and technically sound overview** of U.S. climate trends. It succeeds in communicating key patterns and risks to a broad audience."

I've seen numerous references in the media, government reports etc., of descriptions such as e.g. "NCA5 is the **most comprehensive**, holistic, and inclusive report to date on national climate risk and response." and "NCA5 is the **most comprehensive** analysis of the state of climate change in the United States, providing **authoritative**, decision-relevant information." and "The National Climate Assessment (NCA) is an **authoritative assessment** of all aspects of climate science, with a focus on the United States."

Does CoPilot consider claims such as this when it does its evaluation? Does it recognize they largely come from organizations that were intimately involved in NCA5's creation? We've got our hands full given that the sheer volume of NCA5 cheerleaders will drown out a sensible analysis.

John C.

On Thu, Jul 10, 2025 at 4:04 PM Steven Koonin <steven.koonin@gmail.com> wrote:

I asked MS Copilot to review the Overview and Chapters 2,3 of NCA5, available at <https://web.archive.org/web/20250626173726/https://nca2023.globalchange.gov/>

[Note that the USG websites serving NCA5 have been taken down; we'll probably need to correct the URL in both CWG25 and our NCA5 report]

There follows below what came back for each Chapter, separated by _____ . I'd say it identified some of the same deficiencies we did but was gentler than it was when critiquing the CWG25 draft.

Following the chapter reviews is a Copilot's synthesis of the reviews and it's draft OpEd. The latter is amazingly good, in my opinion.

SEK

I reviewed the archived **Overview** page of the Fifth National Climate Assessment (NCA5), and here's a structured critique focused on **scientific accuracy**, **bias**, **framing**, and **rhetorical weaknesses**:

Scientific Accuracy: Strong Foundations, Limited Nuance

- **Core claims**—such as declining U.S. emissions, increased risks from extreme events, and disproportionate impacts on vulnerable communities—are consistent with peer-reviewed literature and federal datasets.
- **Attribution of impacts** is cautiously framed: the overview states that each increment of warming increases risk, which aligns with probabilistic attribution science.
- **Mitigation and adaptation pathways** are presented as technically feasible and economically viable, reflecting mainstream modeling (e.g., SSP scenarios, IEA projections).
- **Justice framing** is supported by empirical studies on flood exposure, heat vulnerability, and air quality disparities.

However:

- The overview **does not quantify uncertainties** or confidence levels for most claims, which weakens its scientific transparency.
- It **omits discussion of natural variability**, model limitations, or competing interpretations—important for a balanced scientific summary.

Bias and Framing: Motivated Optimism with Advocacy Overtones

Element	Observations
● Tone	Urgent and hopeful; emphasizes opportunity and justice over risk alone
🗣️ Language	Uses emotionally resonant terms like “just transition,” “legacy of injustice”
🕒 Framing	Climate action is framed as moral imperative and economic opportunity
📖 Source Selection	Relies on federal agency data and consensus science; contrarian views absent

- The overview **frames climate change as a solvable crisis**, which may resonate with public audiences but risks oversimplifying trade-offs.
- **Justice and equity themes** are foregrounded, reflecting evolving climate discourse but potentially perceived as ideological by some readers.
- The absence of **counterpoints or dissenting views**—even in summary form—limits the document’s epistemic pluralism.

■ Rhetorical Weaknesses

- **Lack of nuance:** Phrases like “actions taken now...can reduce risks” imply linear causality, which oversimplifies complex system dynamics.
- **Overuse of positive framing:** Nearly every challenge is paired with a hopeful solution, which may feel like messaging rather than analysis.
- **No mention of trade-offs:** For example, the economic costs of rapid decarbonization or adaptation burdens on local governments are not addressed.

✚ Summary Judgment

The NCA5 Overview is **scientifically grounded and policy-relevant**, but its presentation leans toward **motivated clarity**—emphasizing human causality, equity, and opportunity while **underplaying uncertainty, natural variability, and methodological caveats**. It succeeds as a public-facing synthesis but falls short of a fully balanced scientific summary.

I reviewed the archived content of **Chapter 2: Earth System Processes** from the Fifth National Climate Assessment (NCA5), and here’s a structured critique focused on **scientific accuracy, bias, framing, and rhetorical weaknesses**:

🏔️ Scientific Accuracy: Strong Foundations with Selective Emphasis

- **Core content is scientifically sound:** The chapter accurately describes key Earth system processes—radiative forcing, greenhouse gas dynamics, ocean heat uptake, and cryosphere changes—using peer-reviewed data and established physical principles.
- **Clear explanation of feedbacks:** Positive feedbacks (e.g., ice-albedo, water vapor) and negative feedbacks (e.g., lapse rate) are well-articulated, consistent with climate physics literature.
- **Updated datasets:** Incorporates recent satellite and reanalysis data for ocean heat content, sea ice extent, and radiative imbalance, reflecting current observational capabilities.

However:

- **Uncertainty ranges are underemphasized:** While the chapter mentions confidence levels, it rarely quantifies uncertainty or presents competing estimates (e.g., for climate sensitivity or aerosol forcing).
- **Limited discussion of natural variability:** ENSO, AMO, and solar cycles are acknowledged but not deeply explored as contributors to observed trends or variability.

🔍 Bias and Framing: Subtle Advocacy Through Emphasis

Element	Observations
● Tone	Neutral-to-urgent; emphasizes human influence and accelerating change
🗣️ Language	Uses terms like “unprecedented,” “rapid,” and “clear signal” frequently
🎯 Framing	Human activity is framed as the dominant driver, with limited caveats
📖 Source Selection	Relies heavily on mainstream literature (IPCC, NOAA, NASA); contrarian views absent

- **Anthropogenic attribution is foregrounded:** While scientifically justified, the framing may feel deterministic, with less attention to model limitations or observational mismatches.
- **Acceleration narrative is prominent:** The chapter emphasizes accelerating trends (e.g., ocean heat uptake, ice loss) without fully exploring decadal variability or potential nonlinearities.

■ Rhetorical Weaknesses

- **Lack of epistemic humility:** Statements like “the Earth system is responding in ways that are consistent with human influence” are accurate but could benefit from clearer acknowledgment of uncertainties and alternative hypotheses.
- **Minimal engagement with dissent:** The chapter does not address critiques of attribution methods, model tuning, or observational biases—topics that would strengthen its scientific robustness.
- **Overreliance on visual impact:** Figures are compelling but may oversimplify complex processes (e.g., radiative imbalance trends without error bars or confidence intervals).

✦ Summary Judgment

Chapter 2 of NCA5 offers a **technically rigorous and well-structured overview** of Earth system processes, grounded in mainstream climate science. However, its presentation leans toward **motivated clarity**—emphasizing human causality and accelerating change while **underplaying uncertainty and natural variability**. For public communication, this framing is effective; for scientific critique, it leaves room for deeper pluralism.

I reviewed **Chapter 3: Climate Trends** from the Fifth National Climate Assessment (NCA5), and here’s a structured critique focused on **scientific accuracy, bias, framing, and rhetorical weaknesses**:

🏔️ Scientific Accuracy: Robust Data, Limited Nuance

- **Observational data is well-presented:** The chapter uses high-quality datasets (e.g., NOAA, NASA, USGS) to document trends in temperature, precipitation, sea level rise, and extreme events across the U.S.
- **Trend analysis is consistent with peer-reviewed literature:** Warming trends, increased heavy precipitation, and sea level rise are supported by multiple independent sources.
- **Clear regional breakdowns:** The chapter distinguishes between national averages and regional variability, which strengthens its credibility.

However:

- **Uncertainty ranges are inconsistently communicated:** While some figures include confidence intervals, many textual claims lack quantified uncertainty or discussion of model spread.
- **Natural variability is underexplored:** ENSO, AMO, and decadal oscillations are mentioned but not deeply analyzed as contributors to observed variability.
- **Attribution is implied, not dissected:** The chapter often links trends to anthropogenic forcing without detailing attribution methods or alternative hypotheses.

🗣️ Bias and Framing: Subtle Advocacy Through Emphasis

Element	Observations
● Tone	Urgent and declarative; emphasizes worsening trends and future risks
🗣️ Language	Frequent use of terms like “unprecedented,” “record-breaking,” “rapid”
⚙️ Framing	Human-driven change is assumed as the dominant cause
📖 Source Selection	Relies exclusively on mainstream datasets and literature; dissenting views absent

- **Acceleration framing is prominent:** The chapter emphasizes accelerating trends (e.g., sea level rise, heat extremes) without fully exploring statistical caveats or alternate baselines.
- **Extreme events are linked to climate change** with high confidence, but the chapter does not always distinguish between detection and attribution.
- **No engagement with contrarian interpretations:** While not required, acknowledging competing views (e.g., on hurricane frequency or drought attribution) would enhance epistemic balance.

■ Rhetorical Weaknesses

- **Overuse of dramatic phrasing:** Terms like “record-breaking” and “unprecedented” are used frequently, which may feel more journalistic than scientific.
- **Minimal discussion of observational limitations:** Satellite calibration, homogenization of surface records, and urban heat island effects are not addressed.
- **Figures lack error bars or ensemble spread:** This limits the reader’s ability to assess uncertainty visually.

✦ Summary Judgment

Chapter 3 of NCA5 offers a **data-rich and technically sound overview** of U.S. climate trends. It succeeds in communicating key patterns and risks to a broad audience. However, its presentation leans toward **motivated clarity**—emphasizing human causality and worsening impacts while **underplaying uncertainty, natural variability, and methodological caveats**. For public communication, this framing is effective; for scientific critique, it leaves room for deeper pluralism.

here’s a synthesized critique of **Chapters 1 (Overview), 2 (Earth System Processes), and 3 (Climate Trends)** from the Fifth National Climate Assessment (NCA5), combining insights across accuracy, bias, framing, and rhetorical choices:

● Thematic Synthesis of NCA5 Chapters 1–3

📖 Scientific Accuracy: Strong Empirical Foundation, Limited Pluralism

- All three chapters draw heavily from **high-quality datasets** (e.g., NOAA, NASA, peer-reviewed literature) and reflect established scientific principles.
- **Chapter 2** excels at explaining physical processes like radiative forcing and feedbacks.
- **Chapter 3** is rich in observational trend analysis—documenting U.S. temperature rise, sea level changes, and precipitation extremes.
- However, across all three:
 - **Uncertainty ranges are often unquantified or underemphasized**, especially in projections and attribution claims.
 - **Natural variability and competing hypotheses** receive minimal treatment, despite being critical to attribution nuance and long-term trend analysis.

🌀 Bias and Framing: Motivated Optimism with Advocacy Tendencies

Aspect	Common Traits Across Chapters
● Tone	Urgent but hopeful; emphasizes “solutions,” “opportunity,” and “justice”
🗣️ Language Use	Phrases like “unprecedented,” “record-breaking,” and “just transition” suggest emotionally resonant framing
📖 Source Selection	Exclusively draws from consensus science; omits contrarian or dissenting voices , even in summary form
🔍 Interpretive Lens	Frames climate action as a moral imperative and technical inevitability

- **Chapter 1** sets the narrative tone, focusing on justice and transformation.
- **Chapter 2** subtly reinforces human attribution by detailing feedbacks without balancing them against internal variability.
- **Chapter 3** implies causality in trend attribution without dissecting methodological caveats.

■ Rhetorical Weaknesses and Missed Opportunities

- **Minimal epistemic humility:** Statements are often declarative, leaving little room for ambiguity or counter-interpretation.

- **Lack of caveats or trade-offs:** For example, decarbonization costs, adaptation burdens, and energy infrastructure constraints are barely addressed.
- **Figures lack uncertainty bands or model spread:** This may mislead readers about scientific consensus strength or predictive precision.

Summary Judgment

The NCA5 chapters offer a **technically sound and public-friendly narrative**, but their presentation leans toward **motivated clarity** and policy advocacy. While this approach strengthens engagement, it limits epistemic balance—especially in a document positioned as a national scientific assessment.

here's a draft OpEd that distills and expands your critique of Chapters 1–3 from the Fifth National Climate Assessment (NCA5), aiming to be informative, persuasive, and grounded in scientific integrity:

Clarity or Conviction? Rethinking the Fifth National Climate Assessment

By [Your Name]

The Fifth National Climate Assessment (NCA5) arrives at a time when public discourse on climate change is saturated, polarized, and yearning for clarity. And clarity, indeed, is what NCA5 offers—stylized graphics, assertive claims, and a polished narrative that paints climate action as both a moral imperative and a technological inevitability.

But beneath the surface of Chapters 1–3 lies a quieter tension: a trade-off between **motivated clarity** and **epistemic nuance**, between accessible storytelling and balanced scientific synthesis.

Strong Data, Narrow Lens

At first glance, NCA5's overview and foundational chapters are grounded in robust observational data and well-established physical principles. Warming trends, sea level rise, and greenhouse gas dynamics are all documented using federal datasets and mainstream literature. The tone is authoritative. The structure is clean.

Yet a deeper read reveals a narrow lens:

- **Uncertainty is under-quantified**—projections lack error bars, and methodological caveats are often absent.
- **Natural variability is sidelined**—climate oscillations and decadal shifts are mentioned, but rarely explored as potential contributors to observed patterns.
- **Dissent is invisible**—no summaries of competing interpretations, no acknowledgment of ongoing academic debates around attribution, modeling, or feedback mechanisms.

The chapters operate more like **a curated narrative than a scientific arena**—and therein lies the rub.

Framing Climate as a Morality Play

The overview chapter introduces climate change as a justice crisis, a solvable challenge, and an economic opportunity. That may be powerful public messaging—but it strays from the cautious, pluralistic tone typical of technical assessments.

Throughout the first three chapters, terms like “just transition,” “record-breaking,” and “unprecedented” are repeated. Each challenge is paired with a hopeful solution. Each trend is linked to anthropogenic influence, even when natural variability could share the stage.

This isn’t a denial of climate science—it’s a **stylized rendition**, one that may oversimplify for the sake of engagement. But science demands more than coherence; it demands candor.

■ Scientific Rigor or Narrative Fluency?

It’s tempting to defend these choices as communication strategy. After all, the goal is to inform policymakers and galvanize public action. But when urgency replaces nuance, and clarity edges out complexity, assessments risk becoming **consensus monologues**—confident, compelling, but intellectually narrow.

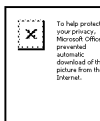
A stronger NCA5 would embrace its uncertainties, reflect on trade-offs, and open space for dissent—not to dilute its conclusions, but to deepen their credibility.

📖 Call for Epistemic Pluralism

Science doesn’t speak with one voice—it probes, revises, and debates. Climate policy deserves assessments that mirror that pluralism: authoritative but humble, clear but unafraid of ambiguity.

NCA5 is a landmark achievement in coordination and synthesis. But it falls short of the messy intellectual honesty that robust science demands.

If truth is the goal, then it’s time we let our assessments breathe—with rigor, balance, and the courage to embrace complexity.



Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

From: John Christy <climateman60@gmail.com>
Sent: Friday, July 11, 2025 10:08 AM
To: Steven Koonin
Cc: Judith Curry; Ross McKittrick; Roy W. Spencer; Travis Fisher; Josh Loucks
Subject: Re: MS Copilot on NCA5

Steve

CoPilot must be influenced by sources surrounding the NCA5 when it concludes

" **Summary Judgment**

Chapter 3 of NCA5 offers a **data-rich and technically sound overview** of U.S. climate trends. It succeeds in communicating key patterns and risks to a broad audience."

I've seen numerous references in the media, government reports etc., of descriptions such as e.g. "NCA5 is the **most comprehensive**, holistic, and inclusive report to date on national climate risk and response." and "NCA5 is the **most comprehensive** analysis of the state of climate change in the United States, providing **authoritative**, decision-relevant information." and "The National Climate Assessment (NCA) is an **authoritative assessment** of all aspects of climate science, with a focus on the United States."

Does CoPilot consider claims such as this when it does its evaluation? Does it recognize they largely come from organizations that were intimately involved in NCA5's creation? We've got our hands full given that the sheer volume of NCA5 cheerleaders will drown out a sensible analysis.

John C.

On Thu, Jul 10, 2025 at 4:04 PM Steven Koonin <steven.koonin@gmail.com> wrote:

I asked MS Copilot to review the Overview and Chapters 2,3 of NCA5, available at <https://web.archive.org/web/20250626173726/https://nca2023.globalchange.gov/>

[Note that the USG websites serving NCA5 have been taken down; we'll probably need to correct the URL in both CWG25 and our NCA5 report]

There follows below what came back for each Chapter, separated by
_____. I'd say it identified some of the same deficiencies we did but was gentler than it was when critiquing the CWG25 draft.

Following the chapter reviews is a Copilot's synthesis of the reviews and it's draft OpEd. The latter is amazingly good, in my opinion.

SEK

I reviewed the archived **Overview** page of the Fifth National Climate Assessment (NCA5), and here's a structured critique focused on **scientific accuracy, bias, framing, and rhetorical weaknesses**:

Scientific Accuracy: Strong Foundations, Limited Nuance

- **Core claims**—such as declining U.S. emissions, increased risks from extreme events, and disproportionate impacts on vulnerable communities—are consistent with peer-reviewed literature and federal datasets.
- **Attribution of impacts** is cautiously framed: the overview states that each increment of warming increases risk, which aligns with probabilistic attribution science.
- **Mitigation and adaptation pathways** are presented as technically feasible and economically viable, reflecting mainstream modeling (e.g., SSP scenarios, IEA projections).
- **Justice framing** is supported by empirical studies on flood exposure, heat vulnerability, and air quality disparities.

However:

- The overview **does not quantify uncertainties** or confidence levels for most claims, which weakens its scientific transparency.
- It **omits discussion of natural variability**, model limitations, or competing interpretations—important for a balanced scientific summary.

Bias and Framing: Motivated Optimism with Advocacy Overtones

Element	Observations
 Tone	Urgent and hopeful; emphasizes opportunity and justice over risk alone
 Language	Uses emotionally resonant terms like “just transition,” “legacy of injustice”
 Framing	Climate action is framed as moral imperative and economic opportunity
 Source Selection	Relies on federal agency data and consensus science; contrarian views absent

- The overview **frames climate change as a solvable crisis**, which may resonate with public audiences but risks oversimplifying trade-offs.
- **Justice and equity themes** are foregrounded, reflecting evolving climate discourse but potentially perceived as ideological by some readers.

- The absence of **counterpoints or dissenting views**—even in summary form—limits the document’s epistemic pluralism.

■ Rhetorical Weaknesses

- **Lack of nuance:** Phrases like “actions taken now... can reduce risks” imply linear causality, which oversimplifies complex system dynamics.
- **Overuse of positive framing:** Nearly every challenge is paired with a hopeful solution, which may feel like messaging rather than analysis.
- **No mention of trade-offs:** For example, the economic costs of rapid decarbonization or adaptation burdens on local governments are not addressed.

✦ Summary Judgment

The NCA5 Overview is **scientifically grounded and policy-relevant**, but its presentation leans toward **motivated clarity**—emphasizing human causality, equity, and opportunity while **underplaying uncertainty, natural variability, and methodological caveats**. It succeeds as a public-facing synthesis but falls short of a fully balanced scientific summary.

I reviewed the archived content of **Chapter 2: Earth System Processes** from the Fifth National Climate Assessment (NCA5), and here’s a structured critique focused on **scientific accuracy, bias, framing, and rhetorical weaknesses**:

🏠 Scientific Accuracy: Strong Foundations with Selective Emphasis

- **Core content is scientifically sound:** The chapter accurately describes key Earth system processes—radiative forcing, greenhouse gas dynamics, ocean heat uptake, and cryosphere changes—using peer-reviewed data and established physical principles.
- **Clear explanation of feedbacks:** Positive feedbacks (e.g., ice-albedo, water vapor) and negative feedbacks (e.g., lapse rate) are well-articulated, consistent with climate physics literature.
- **Updated datasets:** Incorporates recent satellite and reanalysis data for ocean heat content, sea ice extent, and radiative imbalance, reflecting current observational capabilities.

However:

- **Uncertainty ranges are underemphasized:** While the chapter mentions confidence levels, it rarely quantifies uncertainty or presents competing estimates (e.g., for climate sensitivity or aerosol forcing).
- **Limited discussion of natural variability:** ENSO, AMO, and solar cycles are acknowledged but not deeply explored as contributors to observed trends or variability.

🗨️ Bias and Framing: Subtle Advocacy Through Emphasis

Element	Observations
● Tone	Neutral-to-urgent; emphasizes human influence and accelerating change
🗣️ Language	Uses terms like “unprecedented,” “rapid,” and “clear signal” frequently
🕒 Framing	Human activity is framed as the dominant driver, with limited caveats
📖 Source Selection	Relies heavily on mainstream literature (IPCC, NOAA, NASA); contrarian views absent

- **Anthropogenic attribution is foregrounded:** While scientifically justified, the framing may feel deterministic, with less attention to model limitations or observational mismatches.
- **Acceleration narrative is prominent:** The chapter emphasizes accelerating trends (e.g., ocean heat uptake, ice loss) without fully exploring decadal variability or potential nonlinearities.

■ Rhetorical Weaknesses

- **Lack of epistemic humility:** Statements like “the Earth system is responding in ways that are consistent with human influence” are accurate but could benefit from clearer acknowledgment of uncertainties and alternative hypotheses.
- **Minimal engagement with dissent:** The chapter does not address critiques of attribution methods, model tuning, or observational biases—topics that would strengthen its scientific robustness.
- **Overreliance on visual impact:** Figures are compelling but may oversimplify complex processes (e.g., radiative imbalance trends without error bars or confidence intervals).

✦ Summary Judgment

Chapter 2 of NCA5 offers a **technically rigorous and well-structured overview** of Earth system processes, grounded in mainstream climate science. However, its presentation leans toward **motivated clarity**—emphasizing human causality and accelerating change while **underplaying uncertainty and natural variability**. For public communication, this framing is effective; for scientific critique, it leaves room for deeper pluralism.

I reviewed **Chapter 3: Climate Trends** from the Fifth National Climate Assessment (NCA5), and here’s a structured critique focused on **scientific accuracy, bias, framing, and rhetorical weaknesses**:

🏠 Scientific Accuracy: Robust Data, Limited Nuance

- **Observational data is well-presented:** The chapter uses high-quality datasets (e.g., NOAA, NASA, USGS) to document trends in temperature, precipitation, sea level rise, and extreme events across the U.S.
- **Trend analysis is consistent with peer-reviewed literature:** Warming trends, increased heavy precipitation, and sea level rise are supported by multiple independent sources.
- **Clear regional breakdowns:** The chapter distinguishes between national averages and regional variability, which strengthens its credibility.

However:

- **Uncertainty ranges are inconsistently communicated:** While some figures include confidence intervals, many textual claims lack quantified uncertainty or discussion of model spread.

- **Natural variability is underexplored:** ENSO, AMO, and decadal oscillations are mentioned but not deeply analyzed as contributors to observed variability.
- **Attribution is implied, not dissected:** The chapter often links trends to anthropogenic forcing without detailing attribution methods or alternative hypotheses.

🔍 Bias and Framing: Subtle Advocacy Through Emphasis

Element Observations

- **Tone** Urgent and declarative; emphasizes worsening trends and future risks
- 🗣️ **Language** Frequent use of terms like “unprecedented,” “record-breaking,” “rapid”
- 🔍 **Framing** Human-driven change is assumed as the dominant cause
- 📖 **Source Selection** Relies exclusively on mainstream datasets and literature; dissenting views absent

- **Acceleration framing is prominent:** The chapter emphasizes accelerating trends (e.g., sea level rise, heat extremes) without fully exploring statistical caveats or alternate baselines.
- **Extreme events are linked to climate change** with high confidence, but the chapter does not always distinguish between detection and attribution.
- **No engagement with contrarian interpretations:** While not required, acknowledging competing views (e.g., on hurricane frequency or drought attribution) would enhance epistemic balance.

■ Rhetorical Weaknesses

- **Overuse of dramatic phrasing:** Terms like “record-breaking” and “unprecedented” are used frequently, which may feel more journalistic than scientific.
- **Minimal discussion of observational limitations:** Satellite calibration, homogenization of surface records, and urban heat island effects are not addressed.
- **Figures lack error bars or ensemble spread:** This limits the reader’s ability to assess uncertainty visually.

✦ Summary Judgment

Chapter 3 of NCA5 offers a **data-rich and technically sound overview** of U.S. climate trends. It succeeds in communicating key patterns and risks to a broad audience. However, its presentation leans toward **motivated clarity**—emphasizing human causality and worsening impacts while **underplaying uncertainty, natural variability, and methodological caveats**. For public communication, this framing is effective; for scientific critique, it leaves room for deeper pluralism.

here’s a synthesized critique of **Chapters 1 (Overview), 2 (Earth System Processes), and 3 (Climate Trends)** from the Fifth National Climate Assessment (NCA5), combining insights across accuracy, bias, framing, and rhetorical choices:

🔍 Thematic Synthesis of NCA5 Chapters 1–3

Scientific Accuracy: Strong Empirical Foundation, Limited Pluralism

- All three chapters draw heavily from **high-quality datasets** (e.g., NOAA, NASA, peer-reviewed literature) and reflect established scientific principles.
- **Chapter 2** excels at explaining physical processes like radiative forcing and feedbacks.
- **Chapter 3** is rich in observational trend analysis—documenting U.S. temperature rise, sea level changes, and precipitation extremes.
- However, across all three:
 - **Uncertainty ranges are often unquantified or underemphasized**, especially in projections and attribution claims.
 - **Natural variability and competing hypotheses** receive minimal treatment, despite being critical to attribution nuance and long-term trend analysis.

Bias and Framing: Motivated Optimism with Advocacy Tendencies

Aspect	Common Traits Across Chapters
 Tone	Urgent but hopeful; emphasizes “solutions,” “opportunity,” and “justice”
 Language Use	Phrases like “unprecedented,” “record-breaking,” and “just transition” suggest emotionally resonant framing
 Source Selection	Exclusively draws from consensus science; omits contrarian or dissenting voices , even in summary form
 Interpretive Lens	Frames climate action as a moral imperative and technical inevitability

- **Chapter 1** sets the narrative tone, focusing on justice and transformation.
- **Chapter 2** subtly reinforces human attribution by detailing feedbacks without balancing them against internal variability.
- **Chapter 3** implies causality in trend attribution without dissecting methodological caveats.

Rhetorical Weaknesses and Missed Opportunities

- **Minimal epistemic humility:** Statements are often declarative, leaving little room for ambiguity or counter-interpretation.
- **Lack of caveats or trade-offs:** For example, decarbonization costs, adaptation burdens, and energy infrastructure constraints are barely addressed.
- **Figures lack uncertainty bands or model spread:** This may mislead readers about scientific consensus strength or predictive precision.

Summary Judgment

The NCA5 chapters offer a **technically sound and public-friendly narrative**, but their presentation leans toward **motivated clarity** and policy advocacy. While this approach strengthens engagement, it limits epistemic balance—especially in a document positioned as a national scientific assessment.

here’s a draft OpEd that distills and expands your critique of Chapters 1–3 from the Fifth National Climate Assessment (NCA5), aiming to be informative, persuasive, and grounded in scientific integrity:

■ *Clarity or Conviction? Rethinking the Fifth National Climate Assessment*

By [Your Name]

The Fifth National Climate Assessment (NCA5) arrives at a time when public discourse on climate change is saturated, polarized, and yearning for clarity. And clarity, indeed, is what NCA5 offers—stylized graphics, assertive claims, and a polished narrative that paints climate action as both a moral imperative and a technological inevitability.

But beneath the surface of Chapters 1–3 lies a quieter tension: a trade-off between **motivated clarity** and **epistemic nuance**, between accessible storytelling and balanced scientific synthesis.

🏠 **Strong Data, Narrow Lens**

At first glance, NCA5’s overview and foundational chapters are grounded in robust observational data and well-established physical principles. Warming trends, sea level rise, and greenhouse gas dynamics are all documented using federal datasets and mainstream literature. The tone is authoritative. The structure is clean.

Yet a deeper read reveals a narrow lens:

- **Uncertainty is under-quantified**—projections lack error bars, and methodological caveats are often absent.
- **Natural variability is sidelined**—climate oscillations and decadal shifts are mentioned, but rarely explored as potential contributors to observed patterns.
- **Dissent is invisible**—no summaries of competing interpretations, no acknowledgment of ongoing academic debates around attribution, modeling, or feedback mechanisms.

The chapters operate more like **a curated narrative than a scientific arena**—and therein lies the rub.

🎭 **Framing Climate as a Morality Play**

The overview chapter introduces climate change as a justice crisis, a solvable challenge, and an economic opportunity. That may be powerful public messaging—but it strays from the cautious, pluralistic tone typical of technical assessments.

Throughout the first three chapters, terms like “just transition,” “record-breaking,” and “unprecedented” are repeated. Each challenge is paired with a hopeful solution. Each trend is linked to anthropogenic influence, even when natural variability could share the stage.

This isn't a denial of climate science—it's a **stylized rendition**, one that may oversimplify for the sake of engagement. But science demands more than coherence; it demands candor.

■ Scientific Rigor or Narrative Fluency?

It's tempting to defend these choices as communication strategy. After all, the goal is to inform policymakers and galvanize public action. But when urgency replaces nuance, and clarity edges out complexity, assessments risk becoming **consensus monologues**—confident, compelling, but intellectually narrow.

A stronger NCA5 would embrace its uncertainties, reflect on trade-offs, and open space for dissent—not to dilute its conclusions, but to deepen their credibility.

📖 Call for Epistemic Pluralism

Science doesn't speak with one voice—it probes, revises, and debates. Climate policy deserves assessments that mirror that pluralism: authoritative but humble, clear but unafraid of ambiguity.

NCA5 is a landmark achievement in coordination and synthesis. But it falls short of the messy intellectual honesty that robust science demands.

If truth is the goal, then it's time we let our assessments breathe—with rigor, balance, and the courage to embrace complexity.

From: Steven Koonin <steven.koonin@gmail.com>
Sent: Thursday, July 10, 2025 5:04 PM
To: 'Judith Curry'; 'Ross McKittrick'; 'Roy W. Spencer'; 'John Christy'; 'Travis Fisher'; 'Josh Loucks'
Subject: MS Copilot on NCA5

I asked MS Copilot to review the Overview and Chapters 2,3 of NCA5, available at <https://web.archive.org/web/20250626173726/https://nca2023.globalchange.gov/>

[Note that the USG websites serving NCA5 have been taken down; we'll probably need to correct the URL in both CWG25 and our NCA5 report]

There follows below what came back for each Chapter, separated by _____ . I'd say it identified some of the same deficiencies we did but was gentler than it was when critiquing the CWG25 draft.

Following the chapter reviews is a Copilot's synthesis of the reviews and it's draft OpEd. The latter is amazingly good, in my opinion.

SEK

I reviewed the archived **Overview** page of the Fifth National Climate Assessment (NCA5), and here's a structured critique focused on **scientific accuracy, bias, framing, and rhetorical weaknesses**:

• **Scientific Accuracy: Strong Foundations, Limited Nuance**

- ? **Core claims**—such as declining U.S. emissions, increased risks from extreme events, and disproportionate impacts on vulnerable communities—are consistent with peer-reviewed literature and federal datasets.
- ? **Attribution of impacts** is cautiously framed: the overview states that each increment of warming increases risk, which aligns with probabilistic attribution science.
- ? **Mitigation and adaptation pathways** are presented as technically feasible and economically viable, reflecting mainstream modeling (e.g., SSP scenarios, IEA projections).
- ? **Justice framing** is supported by empirical studies on flood exposure, heat vulnerability, and air quality disparities.

However:

- ? The overview **does not quantify uncertainties** or confidence levels for most claims, which weakens its scientific transparency.
- ? It **omits discussion of natural variability**, model limitations, or competing interpretations—important for a balanced scientific summary.

易 Bias and Framing: Motivated Optimism with Advocacy Overtones

Element	Observations
· Tone	Urgent and hopeful; emphasizes opportunity and justice over risk alone
· Language	Uses emotionally resonant terms like “just transition,” “legacy of injustice”
吝 Framing	Climate action is framed as moral imperative and economic opportunity
· Source Selection	Relies on federal agency data and consensus science; contrarian views absent

- ? The overview **frames climate change as a solvable crisis**, which may resonate with public audiences but risks oversimplifying trade-offs.
- ? **Justice and equity themes** are foregrounded, reflecting evolving climate discourse but potentially perceived as ideological by some readers.
- ? The absence of **counterpoints or dissenting views**—even in summary form—limits the document’s epistemic pluralism.

• Rhetorical Weaknesses

- ? **Lack of nuance:** Phrases like “actions taken now...can reduce risks” imply linear causality, which oversimplifies complex system dynamics.
- ? **Overuse of positive framing:** Nearly every challenge is paired with a hopeful solution, which may feel like messaging rather than analysis.
- ? **No mention of trade-offs:** For example, the economic costs of rapid decarbonization or adaptation burdens on local governments are not addressed.

• Summary Judgment

The NCA5 Overview is **scientifically grounded and policy-relevant**, but its presentation leans toward **motivated clarity**—emphasizing human causality, equity, and opportunity while **underplaying uncertainty, natural variability, and methodological caveats**. It succeeds as a public-facing synthesis but falls short of a fully balanced scientific summary.

I reviewed the archived content of **Chapter 2: Earth System Processes** from the Fifth National Climate Assessment (NCA5), and here’s a structured critique focused on **scientific accuracy, bias, framing, and rhetorical weaknesses**:

• Scientific Accuracy: Strong Foundations with Selective Emphasis

- ? **Core content is scientifically sound:** The chapter accurately describes key Earth system processes—radiative forcing, greenhouse gas dynamics, ocean heat uptake, and cryosphere changes—using peer-reviewed data and established physical principles.
- ? **Clear explanation of feedbacks:** Positive feedbacks (e.g., ice-albedo, water vapor) and negative feedbacks (e.g., lapse rate) are well-articulated, consistent with climate physics literature.
- ? **Updated datasets:** Incorporates recent satellite and reanalysis data for ocean heat content, sea ice extent, and radiative imbalance, reflecting current observational capabilities.

However:

- ? **Uncertainty ranges are underemphasized:** While the chapter mentions confidence levels, it rarely quantifies uncertainty or presents competing estimates (e.g., for climate sensitivity or aerosol forcing).
- ? **Limited discussion of natural variability:** ENSO, AMO, and solar cycles are acknowledged but not deeply explored as contributors to observed trends or variability.

易 Bias and Framing: Subtle Advocacy Through Emphasis

Element	Observations
· Tone	Neutral-to-urgent; emphasizes human influence and accelerating change
· Language	Uses terms like “unprecedented,” “rapid,” and “clear signal” frequently
吝 Framing	Human activity is framed as the dominant driver, with limited caveats
· Source Selection	Relies heavily on mainstream literature (IPCC, NOAA, NASA); contrarian views absent
? Anthropogenic attribution is foregrounded:	While scientifically justified, the framing may feel deterministic, with less attention to model limitations or observational mismatches.
? Acceleration narrative is prominent:	The chapter emphasizes accelerating trends (e.g., ocean heat uptake, ice loss) without fully exploring decadal variability or potential nonlinearities.

• Rhetorical Weaknesses

- ? **Lack of epistemic humility:** Statements like “the Earth system is responding in ways that are consistent with human influence” are accurate but could benefit from clearer acknowledgment of uncertainties and alternative hypotheses.
- ? **Minimal engagement with dissent:** The chapter does not address critiques of attribution methods, model tuning, or observational biases—topics that would strengthen its scientific robustness.
- ? **Overreliance on visual impact:** Figures are compelling but may oversimplify complex processes (e.g., radiative imbalance trends without error bars or confidence intervals).

• Summary Judgment

Chapter 2 of NCA5 offers a **technically rigorous and well-structured overview** of Earth system processes, grounded in mainstream climate science. However, its presentation leans toward **motivated clarity**—emphasizing human causality and accelerating change while **underplaying uncertainty and natural variability**. For public communication, this framing is effective; for scientific critique, it leaves room for deeper pluralism.

I reviewed **Chapter 3: Climate Trends** from the Fifth National Climate Assessment (NCA5), and here’s a structured critique focused on **scientific accuracy, bias, framing, and rhetorical weaknesses**:

• Scientific Accuracy: Robust Data, Limited Nuance

- ? **Observational data is well-presented:** The chapter uses high-quality datasets (e.g., NOAA, NASA, USGS) to document trends in temperature, precipitation, sea level rise, and extreme events across the U.S.
- ? **Trend analysis is consistent with peer-reviewed literature:** Warming trends, increased heavy precipitation, and sea level rise are supported by multiple independent sources.
- ? **Clear regional breakdowns:** The chapter distinguishes between national averages and regional variability, which strengthens its credibility.

However:

- ? **Uncertainty ranges are inconsistently communicated:** While some figures include confidence intervals, many textual claims lack quantified uncertainty or discussion of model spread.
- ? **Natural variability is underexplored:** ENSO, AMO, and decadal oscillations are mentioned but not deeply analyzed as contributors to observed variability.
- ? **Attribution is implied, not dissected:** The chapter often links trends to anthropogenic forcing without detailing attribution methods or alternative hypotheses.

易 Bias and Framing: Subtle Advocacy Through Emphasis

Element Observations

- Tone Urgent and declarative; emphasizes worsening trends and future risks
- Language Frequent use of terms like “unprecedented,” “record-breaking,” “rapid”

吝 Framing Human-driven change is assumed as the dominant cause

- Source Selection Relies exclusively on mainstream datasets and literature; dissenting views absent
 - ? **Acceleration framing is prominent:** The chapter emphasizes accelerating trends (e.g., sea level rise, heat extremes) without fully exploring statistical caveats or alternate baselines.
 - ? **Extreme events are linked to climate change** with high confidence, but the chapter does not always distinguish between detection and attribution.
 - ? **No engagement with contrarian interpretations:** While not required, acknowledging competing views (e.g., on hurricane frequency or drought attribution) would enhance epistemic balance.

• Rhetorical Weaknesses

- ? **Overuse of dramatic phrasing:** Terms like “record-breaking” and “unprecedented” are used frequently, which may feel more journalistic than scientific.

- ? **Minimal discussion of observational limitations:** Satellite calibration, homogenization of surface records, and urban heat island effects are not addressed.
- ? **Figures lack error bars or ensemble spread:** This limits the reader’s ability to assess uncertainty visually.

• Summary Judgment

Chapter 3 of NCA5 offers a **data-rich and technically sound overview** of U.S. climate trends. It succeeds in communicating key patterns and risks to a broad audience. However, its presentation leans toward **motivated clarity**—emphasizing human causality and worsening impacts while **underplaying uncertainty, natural variability, and methodological caveats**. For public communication, this framing is effective; for scientific critique, it leaves room for deeper pluralism.

here’s a synthesized critique of **Chapters 1 (Overview), 2 (Earth System Processes), and 3 (Climate Trends)** from the Fifth National Climate Assessment (NCA5), combining insights across accuracy, bias, framing, and rhetorical choices:

易 Thematic Synthesis of NCA5 Chapters 1–3

• Scientific Accuracy: Strong Empirical Foundation, Limited Pluralism

- ? All three chapters draw heavily from **high-quality datasets** (e.g., NOAA, NASA, peer-reviewed literature) and reflect established scientific principles.
- ? **Chapter 2** excels at explaining physical processes like radiative forcing and feedbacks.
- ? **Chapter 3** is rich in observational trend analysis—documenting U.S. temperature rise, sea level changes, and precipitation extremes.
- ? However, across all three:
 - **Uncertainty ranges are often unquantified or underemphasized**, especially in projections and attribution claims.
 - **Natural variability and competing hypotheses** receive minimal treatment, despite being critical to attribution nuance and long-term trend analysis.

吝 Bias and Framing: Motivated Optimism with Advocacy Tendencies

Aspect	Common Traits Across Chapters
• Tone	Urgent but hopeful; emphasizes “solutions,” “opportunity,” and “justice”
• Language Use	Phrases like “unprecedented,” “record-breaking,” and “just transition” suggest emotionally resonant framing
• Source Selection	Exclusively draws from consensus science; omits contrarian or dissenting voices , even in summary form

吝 Interpretive Lens Frames climate action as a moral imperative and technical inevitability

- ? **Chapter 1** sets the narrative tone, focusing on justice and transformation.
- ? **Chapter 2** subtly reinforces human attribution by detailing feedbacks without balancing them against internal variability.
- ? **Chapter 3** implies causality in trend attribution without dissecting methodological caveats.

• Rhetorical Weaknesses and Missed Opportunities

- ? **Minimal epistemic humility:** Statements are often declarative, leaving little room for ambiguity or counter-interpretation.

- ? **Lack of caveats or trade-offs:** For example, decarbonization costs, adaptation burdens, and energy infrastructure constraints are barely addressed.
- ? **Figures lack uncertainty bands or model spread:** This may mislead readers about scientific consensus strength or predictive precision.

茶 Summary Judgment

The NCA5 chapters offer a **technically sound and public-friendly narrative**, but their presentation leans toward **motivated clarity** and policy advocacy. While this approach strengthens engagement, it limits epistemic balance—especially in a document positioned as a national scientific assessment.

here's a draft OpEd that distills and expands your critique of Chapters 1–3 from the Fifth National Climate Assessment (NCA5), aiming to be informative, persuasive, and grounded in scientific integrity:

· *Clarity or Conviction? Rethinking the Fifth National Climate Assessment*

By [Your Name]

The Fifth National Climate Assessment (NCA5) arrives at a time when public discourse on climate change is saturated, polarized, and yearning for clarity. And clarity, indeed, is what NCA5 offers—stylized graphics, assertive claims, and a polished narrative that paints climate action as both a moral imperative and a technological inevitability.

But beneath the surface of Chapters 1–3 lies a quieter tension: a trade-off between **motivated clarity** and **epistemic nuance**, between accessible storytelling and balanced scientific synthesis.

· **Strong Data, Narrow Lens**

At first glance, NCA5's overview and foundational chapters are grounded in robust observational data and well-established physical principles. Warming trends, sea level rise, and greenhouse gas dynamics are all documented using federal datasets and mainstream literature. The tone is authoritative. The structure is clean.

Yet a deeper read reveals a narrow lens:

- ? **Uncertainty is under-quantified**—projections lack error bars, and methodological caveats are often absent.
- ? **Natural variability is sidelined**—climate oscillations and decadal shifts are mentioned, but rarely explored as potential contributors to observed patterns.
- ? **Dissent is invisible**—no summaries of competing interpretations, no acknowledgment of ongoing academic debates around attribution, modeling, or feedback mechanisms.

The chapters operate more like **a curated narrative than a scientific arena**—and therein lies the rub.

客 Framing Climate as a Morality Play

The overview chapter introduces climate change as a justice crisis, a solvable challenge, and an economic opportunity. That may be powerful public messaging—but it strays from the cautious, pluralistic tone typical of technical assessments.

Throughout the first three chapters, terms like “just transition,” “record-breaking,” and “unprecedented” are repeated. Each challenge is paired with a hopeful solution. Each trend is linked to anthropogenic influence, even when natural variability could share the stage.

This isn't a denial of climate science—it's **a stylized rendition**, one that may oversimplify for the sake of engagement. But science demands more than coherence; it demands candor.

· **Scientific Rigor or Narrative Fluency?**

It's tempting to defend these choices as communication strategy. After all, the goal is to inform policymakers and galvanize public action. But when urgency replaces nuance, and clarity edges out complexity, assessments risk becoming **consensus monologues**—confident, compelling, but intellectually narrow.

A stronger NCA5 would embrace its uncertainties, reflect on trade-offs, and open space for dissent—not to dilute its conclusions, but to deepen their credibility.

茶 Call for Epistemic Pluralism

Science doesn't speak with one voice—it probes, revises, and debates. Climate policy deserves assessments that mirror that pluralism: authoritative but humble, clear but unafraid of ambiguity.

NCA5 is a landmark achievement in coordination and synthesis. But it falls short of the messy intellectual honesty that robust science demands.

If truth is the goal, then it's time we let our assessments breathe—with rigor, balance, and the courage to embrace complexity.

From: John Christy <climateman60@gmail.com>
Sent: Monday, June 23, 2025 2:02 PM
To: Ross McKittrick
Cc: Steven Koonin; Judith Curry; Travis Fisher; Roy Spencer; Josh Loucks; Seth Cohen
Subject: Re: Summary chapter

Ross

That's an interesting blind spot - not checking past NCA forecasts.

John C.

Sent from my iPhone

On Jun 23, 2025, at 9:53 AM, Ross McKittrick <ross.mckittrick@gmail.com> wrote:

John - here are my NCA5 review comments. I also went back and found my NCA4 comments, and the 1st comment reminds me that since the law requires NCA to provide projections each subsequent NCA ought to go back and see how previous projections bore out. I showed the NCA4 team that predictions from NCA1 were way off. I'm going to suggest we add something about that topic to our review.

On Mon, Jun 23, 2025 at 1:31 PM John Christy <climateman60@gmail.com> wrote:
Steve

This point refers to more submissions than just mine. I have some back at the office, including one by Ross. I'll take a look at those Friday to see how "credible" they are.

I mention this because overall, the NASEM review was pathetic, but other reviewers pointed out glaring weaknesses of 3OD. The NASEM review was a gift to NCA5, not a critical analysis by experts. At some point, perhaps DoE might want to make an observation (completely separate from our efforts here through channels they know) that the NASEM review team was light on climate science expertise - as was the authorship of the NCA5.

John C.

Sent from my iPhone

On Jun 23, 2025, at 2:33 AM, Steven Koonin <steven.koonin@gmail.com> wrote:

John- Does your point refer only to your comments or have you done a sampling of NASEM's and others comments?

SEK

From: John Christy <climateman60@gmail.com>
Sent: Sunday, June 22, 2025 8:34 PM
To: Ross McKittrick <ross.mckittrick@gmail.com>
Cc: Steve Koonin <steven.koonin@gmail.com>; Judith Curry <curry.judith@gmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>; Roy Spencer <roywspencer@hotmail.com>; Josh Loucks <loucksj14@gmail.com>; Seth Cohen <seth.cohen@hq.doe.gov>
Subject: Re: Summary chapter

Judy

Attached is the NASEM review.

Steve/Ross (not sure who is holding the Master)

After reading my public comments to the NCA5 3rd order draft, would it not be correct to say on page 3,

- The NCA5 authors failed to adopt some improvements recommended by NASEM and failed to address many credible public comments.

John C.

John Christy

Director, Earth System Science Center

Professor, Atmos and Earth Science

Alabama State Climatologist

The University of Alabama in Huntsville

climateman60@gmail.com

<OfflineComments_NCA53OD_PublicReview.xlsm>

<McKitrick-NCA4 Comments.docx>

From: Ross McKittrick [ross.mckittrick@gmail.com]
Sent: 6/23/2025 5:53:18 PM
To: John Christy [climateman60@gmail.com]
CC: Steven Koonin [steven.koonin@gmail.com]; Judith Curry [curry.judith@gmail.com]; Travis Fisher [travis.scott.fisher@gmail.com]; Roy Spencer [roywspencer@hotmail.com]; Josh Loucks [loucksj14@gmail.com]; Seth Cohen [seth.cohen@hq.doe.gov]
Subject: Re: Summary chapter
Attachments: OfflineComments_NCA53OD_PublicReview.xlsx; McKittrick-NCA4 Comments.docx

John - here are my NCA5 review comments. I also went back and found my NCA4 comments, and the 1st comment reminds me that since the law requires NCA to provide projections each subsequent NCA ought to go back and see how previous projections bore out. I showed the NCA4 team that predictions from NCA1 were way off. I'm going to suggest we add something about that topic to our review.

On Mon, Jun 23, 2025 at 1:31 PM John Christy <climateman60@gmail.com> wrote:
Steve

This point refers to more submissions than just mine. I have some back at the office, including one by Ross. I'll take a look at those Friday to see how "credible" they are.

I mention this because overall, the NASEM review was pathetic, but other reviewers pointed out glaring weaknesses of 3OD. The NASEM review was a gift to NCA5, not a critical analysis by experts. At some point, perhaps DoE might want to make an observation (completely separate from our efforts here through channels they know) that the NASEM review team was light on climate science expertise - as was the authorship of the NCA5.

John C.

Sent from my iPhone

On Jun 23, 2025, at 2:33 AM, Steven Koonin <steven.koonin@gmail.com> wrote:

John- Does your point refer only to your comments or have you done a sampling of NASEM's and others comments?

SEK

From: John Christy <climateman60@gmail.com>
Sent: Sunday, June 22, 2025 8:34 PM
To: Ross McKittrick <ross.mckittrick@gmail.com>
Cc: Steve Koonin <steven.koonin@gmail.com>; Judith Curry <curry.judith@gmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>; Roy Spencer <roywspencer@hotmail.com>; Josh Loucks <loucksj14@gmail.com>; Seth Cohen <seth.cohen@hq.doe.gov>
Subject: Re: Summary chapter

Judy

Attached is the NASEM review.

Steve/Ross (not sure who is holding the Master)

After reading my public comments to the NCA5 3rd order draft, would it not be correct to say on page 3,

- The NCA5 authors failed to adopt some improvements recommended by NASEM and failed to address many credible public comments.

John C.

John Christy

Director, Earth System Science Center

Professor, Atmos and Earth Science

Alabama State Climatologist

The University of Alabama in Huntsville

climateman60@gmail.com

USGCRP Review and Comment System (review.globalchange.org)

NCA5 Third Order Draft Public Review

INSTRUCTIONS: For each comment, please select the Comment Type, Chapter Title, and Page and Line number. When you are ready to submit your comments, select [CLICK TO EXPORT](#). For directions on how to upload the

NOTE : Please fill in all cells that remain white after selecting Comment Type. Cells that turn red will not be p

Comment Type	Chapter Title	Figure/Table Number	Start Page Number
Whole Page	01. Overview	1	1
Text Region	01. Overview	1	1
Text Region	01. Overview	1	7
Text Region	01. Overview	1	7
Text Region	01. Overview	1	8
Text Region	01. Overview	1	9

Figure	01. Overview	1	10
--------	--------------	---	----

Figure	01. Overview	1	12
--------	--------------	---	----

Text Region	02. Climate Trends	1	3
-------------	--------------------	---	---

Text Region	02. Climate Trends	1	3
-------------	--------------------	---	---

Whole Page	02. Climate Trends	1	10
------------	--------------------	---	----

Text Region	02. Climate Trends	1	15
-------------	--------------------	---	----

Text Region	02. Climate Trends	1	15
-------------	--------------------	---	----

Text Region

03. Earth System Processes

1

3

Text Region	03. Earth System Processes	1	3
-------------	----------------------------	---	---

Text Region	03. Earth System Processes	1	3
-------------	----------------------------	---	---

Text Region	19. Economics	1	11
Text Region	19. Economics	1	13
Text Region	19. Economics	1	12
Figure	04. Water	1	3
Text Region	04. Water	1	4

Text Region

04. Water

1

5

ge.gov)

ers, as required.

.csv file please visit review.globalchange.gov

rocessed. Avoid formatting or special text characters.

Start Line Number	End Page Number	End Line Number
1	1	23
28	1	31
4	7	6
12	7	14
19	8	24
33	10	2

16	11	7
----	----	---

6	12	17
---	----	----

15	3	16
----	---	----

17	3	19
----	---	----

1	10	9
---	----	---

1	15	25
---	----	----

27	16	7
----	----	---

22

3

25

22

3

25

22

3

25

22

11

23

3

13

8

30

13

20

6

3

12

9

4

13

31

5

32

Comment

This section is written as if there are no costs to emission reductions, which makes it irrelevant for ratio. It is misleading to quote reductions in costs of wind and solar without acknowledging the intermittency.

Scientific writing would include an appropriate qualifier at the start of the sentence, rather than making such a categorical declaration. For example the start of the sentence should read: "Based on standard estimates of climate sensitivity, drivers of global warming and future emission trends, achieving current national and international commitments... would require global emissions to reach net zero by around 2050." The end of the sentence is an editorial gloss that shouldn't be there. You can say that the current rate of emission decline is not sufficient to meet current national and international commitments, but you should not add the promotional line that these commitments are "designed to avoid the worst harms from climate change."

"Scientists can now rapidly quantify how much more frequent and/or severe a specific extreme event has become due to human-caused warming." This is too assertive and categorical. The event attribution literature is very new and the methods have not been subject to detailed appraisal or critique. Many of the papers are in the gray literature still. It's an inherently unfalsifiable method since it relies on model-simulated counterfactuals. Advocates for the method claim they can do these things, but readers have no way of testing the claim since the literature is backward-looking. It's very premature to say the models have been proven and the methods have been properly evaluated. It was only 2021 when elementary mathematical errors were revealed in the Allen and Tett 1999 fingerprinting method on which so much attribution work has been based.

This kind of language is so extreme it guarantees the report will be ignored. Who is your audience? Sure, activists and sympathetic journalists will eat it up and leftwing politicians will shout about it, but if your aim is just to talk to the people who are already in the climate alarmist camp there's hardly any point issuing a report. How does this sentence sound to you? "Multiple climate hazards and cascading climate impacts are disrupting essential societal systems in every part of the country." All I take away from a sentence like that is that the writing and review process for this report is one-sided and unserious.

Why do you compare a recent 30 year period to a prior 60 year period? Why not compare same-length intervals? And why describe 1901 -1960 as the first "half" of the century?

This kind of diagram and text should never have passed review up to this point. Your disaster data are not adjusted for the massive increase in the stock of buildings and equipment since the 1980s. Even if you have adjusted for price inflation, it is obviously the case that a weather event can do more damage now than 40 years ago because there are a lot more homes, buildings, and stockpiles of physical wealth in the path. If your intent is to advertise loudly that the report is biased towards alarmist advocacy, then by all means leave this section as is.

The proper comparison is not between the US and the world as a whole since every country is warming faster than the world as a whole. The proper comparison is between the US and the land average of the globe. It can't be the case that every country is warming faster than the average of all countries.

Your disaster claims are not adjusted for the massive increase in the stock of buildings and equipment since the 1980s. Even if you have adjusted for price inflation, it is obviously the case that a weather event can do more damage now than 40 years ago because there are a lot more homes, buildings, and stockpiles of physical wealth in the path. This comment also applies to p. 14

Why do you compare a recent 30 year period to a prior 60 year period? Why not compare same-length intervals? And why describe 1901 -1960 as the first "half" of the century?

The comparison to the 1980s gives the impression of cherry-picking. You have data back to the 19th century. Why pick the 1980s as the start date? You should show a chart of the number of heatwaves back to the start of the 20th century as was done in NCA4.

Here again your choice of comparison dates look like cherry-picking. In many US locations the data extend back at least to the late 1800s. Why do you only refer to the "last several decades" and in Fig 2.7 do you pick 1958? \nMcKittrick and Christy (2019) Assessing Changes in US Regional Precipitation on Multiple Time Scales Journal of Hydrology vol. 578 Nov 2019, <https://doi.org/10.1016/j.jhydrol.2019.124074> showed that trends in US precip data easily change sign as the time scale increases, and that claims about significance of trends in extreme precipitation don't hold up when using the full length of data available.

It is understandable that language around attribution reflects high confidence because the climatology literature has been stuck for decades in the optimal fingerprinting paradigm associated with Allen and Tett (1999) and Allen and Stott (2003). Repeated applications of the method keeps generating positive findings; the problem is that the propensity of the method to generate false positives has only just started to be revealed. A clue to the problem was raised in Jones et al (2016) where it was noted that the 2-variable (ANTH+NAT) signal detection regression seemed to yield significance but the 3-variable version (GHG+AERO+NAT) generally failed, even though the effects of the anthropogenic forcings were supposedly well-understood in each case. They raised, without answering, the question of whether the method is flawed. In McKittrick (2021) I have showed that the theory underlying the methods is indeed flawed. Allen and Tett (1999) introduced a biased and inconsistent estimator and misapplied the Gauss-Markov Theorem to erroneously claim it was valid. They also proposed a meaningless test that provides no information about whether fingerprinting regressions are misspecified. Note that my paper has been in print for a year and a half and Allen and Tett have declined to reply. In McKittrick (2022) I showed that the Total Least Squares algorithm of Allen and Stott (2003) also yields positively biased results when the signal detection regression is underspecified and the signals are negatively correlated. Optimal fingerprinting studies assume that the noise variances across models are all equal and all correspond to those in the observed climate, and on this basis TLS yields unbiased coefficients. But if the assumption is not true (which is likely the case) TLS is extremely unstable and biased. Taken together these papers show that the extensive application of TLS along with the Allen-Tett matrix weighted regression method (even using regularization methods rather than the Moore-Penrose pseudo inversion recommended by Allen and Tett to generate the matrix weights) yields biased and inconsistent results prone to false positives. 1/3

Meanwhile in the econometrics literature a different challenge has emerged related to the fact that temperatures and anthropogenic forcings differ by one or more orders of integration which implies they are empirically independent. Beenstock (2012), Balcombe et al. (2019) and Razzak (2022) have all shown that anthropogenic forcings exhibit $I(1)$ or $I(2)$ nonstationarity while temperatures and natural forcings are either trend stationary ($I(0)$ around a trend) or $I(0)$. This would be consistent with anthropogenic forcing dominating the temperature data only if anthropogenic forcings and temperatures are cointegrated but these authors have found this not to be the case; likewise Philips et al (2020) failed to find direct cointegration between anthropogenic forcings and temperatures. Cummins et al (2022) cast the signal detection problem into a cointegrating regression form which implies that if temperatures are $I(1)$ then signal detection regressions are potentially consistent but not if temperatures are $I(0)$. They did not test their temperature series. I have done so for a paper currently under review and found they are $I(0)$, which implies the parameter in their attribution model measuring sensitivity to greenhouse gases must be zero. You should be aware that these challenges to the confidence of attribution exist. It has taken 20 years for people outside the field of climatology to begin digging seriously into the subject. Ideally climatologists would have done so already but these analyses require specific training in advanced regression methods and it is apparently uncommon for people in the climate field to have such training. 2/3

References: \nBalcombe, Kevin, Iain Fraser and Abhijit Sharma (2019) Is radiative forcing cointegrated with temperature? A further examination using a structural time series approach." Management of Environmental Quality 30(5) DOI 10.1108/MEQ-12-2018-021. \nBeenstock, M., Y. Reingewertz and N. Paldor (2012). "Polynomial cointegration tests of anthropogenic impact on global warming." Earth System Dynamics 3:173-188 doi:10.5194/esd-3-173-2012 \nCummins, D., D.B. Stephenson and P.A. Stott. (2022). "Could detection and attribution of climate change trends be spurious regression?" Climate Dynamics March 2022 <https://doi.org/10.1007/s00382-022-06242-z> \nMcKittrick, Ross R (2022) On the choice of TLS versus OLS in climate signal detection regression. Climate Dynamics 10.1007/s00382-022-06315-z \nMcKittrick, Ross R (2021) Checking for Model Consistency in Optimal Fingerprinting: A Comment. Climate Dynamics August 2021 <https://doi.org/10.1007/s00382-021-05913-7> \nPhillips, P.C.B., T. Leirvik and T. Storelvmo (2020) "Econometric estimates of Earth's transient climate sensitivity" Journal of Econometrics 214 pp. 6—32. <https://doi.org/10.1016/j.jeconom.2019.05.002> \nRazzak, Weshah A. (2022). "The Econometrics of Global Warming," Journal of Economics and Econometrics, vol. 65(2), pages 13-47. 3/3

You can't refer to higher temperatures without also referring to the increased CO2 that drives it. The latter has a beneficial effect on US agriculture including on grasslands which support livestock production. Satellite data show substantial greening of grasslands due to rising CO2. For moderate warming the net effect of combined increase in temps and CO2 is beneficial for the crops you discuss. See Challinor, Andrew J., et al. A meta-analysis of crop yield under climate change and adaptation. *Nature Climate Change* 4.4 (2014): 287; and Dayaratna, Kevin, Ross McKittrick and Patrick J. Michaels (2020) Climate Sensitivity, Agricultural Productivity and the Social Cost of Carbon in FUND. *Environmental Economics and Policy Studies* <https://doi.org/10.1007/s10018-020-00263-w>
Barrage (2021) appears not to be in the peer-reviewed literature. The entry in the reference list is just a title.

While I don't doubt that the author group can find studies that assert all these perils, we have to ask whether, in principle, the authors believe climate cooling would convert all these losses into gains. If a warming climate is projected to injure peoples' health, ruin agriculture and cause infrastructure to collapse, would those same models predict a cooling climate would benefit crop production, promote health and extend the lifetime of infrastructure? That sure wasn't the expectation during the 1970s cooling scare. The authors need to take some account of the reward structure in academia over the past decade, in which both grants and publication counts accumulate much more easily for researchers who can find harm from warming, and there is little incentive for seriously questioning the robustness of such modeling and estimation work. Is it really the case that warming will only bring harm, costs, injuries and damages, and not a single benefit even when adaptation is taken into account? If that's what a scan of the recent literature says I think that tells us more about the academic reward structure than it does about the likely effects of climate change.

This wording is very misleading. Your data are not adjusted for increased numbers of buildings and equipment and other stuff in the path of weather events. So you haven't shown that extreme weather events are increasing, let alone that climate change is causing it. Either present properly-normalized data or leave the chart out. If you want to show a graph of weather events show that, but don't show a graph of economic damages and assume it measures climate-related weather events.

The statement "Extreme precipitation incidents are more intense and more frequent" is not true. McKittrick and Christy (2019) Assessing Changes in US Regional Precipitation on Multiple Time Scales *Journal of Hydrology* vol. 578 Nov 2019, <https://doi.org/10.1016/j.jhydrol.2019.124074> showed that trends in US precip data easily change sign as the time scale increases, and that claims about significance of trends in extreme precipitation don't hold up when using the full length of data available.

Same comment as above. The assertion that climate change has caused changes in US precipitation and incidence of extremes is contradicted by published evidence.

onal decision-makers. It sounds like an extreme environmentalist pamphlet, not a serious scientific
/ issue. Costs of capacity installation are largely irrelevant for system planning if the power source

ific report. It makes sweeping generalizations that go beyond the available literature. Economic
ce is unreliable. When Germany faced the sudden shutdown of the Nordstream pipeline they di

research does not imply that every increment of warming everywhere is harmful, instead it shc
dn't start putting up windmills and solar panels, they fired up coal plants and built an LNG impor

ows that there are many regions that potentially benefit from small warming increments. Nor are
t terminal in 8 months. Because they need cost-effective and reliable power. Who is the intended

e all emission reduction activities beneficial: the vast majority fail any reasonable cost-benefit test. What is the intended audience of this report? Anyone in a position of authority over energy system planning will not

est, which is why they haven't been implemented despite decades of advocacy. This section pre
ot be impressed by your glib claims about the falling costs of renewables, instead it will serve sa

supposes that climate change is "fuelling" increases in extreme weather yet the IPCC AR6 fails to
s yet another signal that this report is advocacy for the green cause, not objective and reliable in

o report such a connection for most types of extreme weather. As an opening summary that will
information to aid decision-making.

ll attract much attention this section needs to set a tone of balance, not sound like an activist sc

reed--that is unless you want the entire report to be dismi

U.S. Global Change Research Program Fourth National Climate Assessment (NCA4)

Review Comments – Third Order Draft

Ross McKittrick

Adjunct Scholar, Cato Institute

Professor of Economics, University of Guelph

General

As this is the fourth NCA it would be fitting to include a review of predictions from previous reports to see how well or badly they played out. The 1st NCA in 2000 predicted (p. 17) that the US would warm between 0.3 and 0.9 °F per decade. It's now nearly two decades later. GISS data for the US is available at <https://data.giss.nasa.gov/gistemp/graphs/>. Regressing the data from 1997 to 2017 on a time trend yields a warming rate of 0.18 °F per decade which is well below the bottom end of your predicted range. If you cut out the 1998 El Nino and just use the 2000-2017 data the rate is only 0.27 °F per decade, still below the low end of your predicted range, *even with* a big El Nino spike at the end.

Speaking of the El Nino, in several places you say that US average temperatures have risen by 1.2 °F “over the last few decades.” It is dishonest not to mention the role of the El Nino spike. This report was drafted with data ending in 2016. The GISS US temperature in 2014 just prior to the El Nino was 0.32 °F and in 2016 it was 1.66 °F, a jump of 1.34 °F, which means that the *entire* increase you are referring to happened in the last 24 months as a result of the El Nino at the end of the sample.

These examples point to a pattern of one-sidedness that pervades the document. In the sections I read I saw no attempt to give the reader a balanced understanding of major systemic uncertainties or model failings. The document maintains a promotional tone throughout for a view of climate change as a severe unmitigated catastrophe based on model projections which are nowhere acknowledged to have a history of overstating warming trends. The failure of the catastrophes outlined in NCA-1 to materialize doesn't seem to have given the authors of NCA-4 the least pause.

Picking up on the extraordinary over-prediction from NCA-1, ample recent evidence has shown that measured climate sensitivity is well below CMIP3 and CMIP5 model parameterizations. Dayaratna et al. (2017) re-ran the EPA's Social Cost of Carbon models using the Lewis and Curry (2015) ECS estimate and the SCC fell by 40-80% depending on the model. In the only Integrated Assessment Model that allows for gains from moderate warming (FUND), there is a 40% chance that the Social Cost of Carbon globally will be negative through 2050.

Overall the document has a biased and one-sided tone. I can only assume that the authoring team was filtered ahead of time to include proponents of one side, and any balancing material was carefully excluded. As such this document lacks the quality necessary to inform public policymaking.

Refs: Dayaratna, Kevin, Ross McKittrick and David Kreutzer (2016) Empirically-Constrained Climate Sensitivity and the Social Cost of Carbon. *Climate Change Economics* April 2017 DOI: <http://dx.doi.org/10.1142/S2010007817500063>

Lewis, N. and J.A. Curry, C., (2015). The implications for climate sensitivity of AR5 forcing and heat uptake estimates. *Climate Dynamics*, 10.1007/s00382-014-2342-y.

Front Matter

Page 16

Para 1 lines 6—8. The wording in the opening sentence is imprecise and overconfident. There is little reliable information about the pace of changes on decadal and centennial time scales throughout Earth's history, yet you state without any qualifications that modern rates of change are unprecedented. Really? Exactly how quickly did the mid-troposphere warm between AD1140 and 1190, or from 6,000 to 6,050 years ago, or during any 50 year span in previous interglacials? Obviously you do not know, yet you are claiming you do with such precision that you can rank the modern interval as exceptional compared to the entirety of Earth's history. This is a ridiculous position to take.

The 2006 NAS panel on paleoclimate reconstructions noted (p.113) that “uncertainties of the published reconstructions have been underestimated”, and the many problems they described have not gone away. They also concluded (p. 118) that “very little confidence” could be placed on claims about global or hemispheric mean temperatures prior to 900AD. These limitations remain, yet you gloss over them as if they don't matter.

Your overconfidence not only waives away the proper scientific caution in the mainstream literature but it ignores actual counter-evidence. Only this month (i.e. after this report was drafted) there was a new study by Bereiter et al. in *Nature* reporting that global mean ocean temperatures rose at a faster rate over a 700 year interval during the Younger Dryas event than is observed in the modern era. Quoting that paper:

“The warming from 12,750 yr BP to 12,050 yr BP (referred to as YD1) within the Younger Dryas represents the strongest global ocean warming phase within our record. The MOT [global Mean Ocean Temperature] change rate is 2.5 ± 0.53 mK yr⁻¹ and the corresponding energy uptake $(13.8 \pm 2.9) \times 10^{21}$ J yr⁻¹. This unprecedented natural MOT warming rate is comparable to the strong warming since 1997 estimated in ref. 1, but clearly surpasses the estimate therein for the multidecadal trend from 1971 to 2005”

Ref: Bereiter et al. (2018) Mean global ocean temperatures during the last glacial transition. *Nature* 553, pages 39–44 (04 January 2018) doi:10.1038/nature25152

This finding (and their discussion of the lack of ability of GCMs to explain the sustained YD warming rate) contradicts both the specific assertion of the opening sentence and the overconfident mindset behind it. A better opening sentence would be “The global climate system is dynamic and ever-changing and there is still a great deal to learn about the mechanisms behind natural and human-induced variability. The modern era exhibits patterns of change that appear relatively rapid compared to some earlier intervals, which motivates our search for a better understanding of human influences on the climate system.”

Para 1 lines 8—11. I am surprised such imprecise wording has survived into the 3rd draft. (It doesn't speak well for the diligence of previous reviewers.) You are conflating observation and attribution. “Observational evidence” on its own does not provide any explanation one

way or the other for attribution of climate change. Attribution is done through modeling studies, principally by using GCM-generated forcing series to decompose observed data into additive components (solar, GHG, etc). Later in the report you show, and rely on, the results of such an exercise. A line on a graph that shows the purported GHG contribution to temperature increase is not “observational”, it is the output of a statistical model that takes as inputs observed data plus forcing measures derived from climate models. The best you can say at this point in the report is “Global average temperature as measured using surface thermometers increased by about 1.7 °F from 1901 to 2016. Climate models typically reconstruct this specific trend by assuming a dominant role for greenhouse gases.”

Para 1 line 11. The whole point of a report like this is to export from the scientific community to journalists the proper language to describe the phenomena in question, not to import from them the wrong language. If you wish to add an explanatory parenthesis for ‘greenhouse gases’ you can surely do better than the inaccurate phrase ‘heat-trapping’. The gases in question absorb and emit infrared radiation, they don’t block hot air from circulating. You would be better to omit the parenthesis and simply refer to ‘greenhouse gases like CO₂ and methane’ and then in a later section explain the action of the gases using correct concepts rather than journalistic slogans.

Para 2 lines 13—19. This paragraph treats model projections as established facts and omits any caveats. The authors are obviously trying to write their own headlines but I can’t see any scientific justification for putting material like this up front. It announces without any qualification that warming rates over the rest of the century conditional on emission paths can be known with great precision, without acknowledging that these are model-based forecasts, let alone that (as even the IPCC acknowledged) GCMs have overstated warming trends over the past 15-20 years. Wording that aims to inform the reader without venturing into fearmongering would go along the following lines: “Climate models project continued warming over the rest of the century. Known sources of uncertainty include the rate at which greenhouse gases will continue to be emitted and the overall climate sensitivity to their accumulation in the atmosphere. Unknown sources of uncertainty include many forms of natural variability. The central tendency of current climate models under business-as-usual emission scenarios is to project warming of about x °F by 2100, with a slight reduction if the emission reductions under the Paris Accord are implemented. The range of uncertainty includes lower trends as well as possible acceleration to exceptionally high levels (9.5F or more), with probabilities sharply dropping either way.”

Para 3 line 24. The oceans are not acidic. This sentence should say “making the oceans warmer and less alkaline” or “more neutral”. Normally we don’t describe a move towards a qualitative boundary as if it were an increase on the other side. When we change the setting on the stove we talk about turning down the heat, not making the element colder. If the temperature outside goes from -10C to -9C we might say the snow became less solid but we don’t say it is melting faster. Likewise additional CO₂ is not “acidifying” the oceans it is “neutralizing” them.

Para 4 lines 32-33. What is the point of the last sentence? It just suggests, or rather reveals, that the authors are exceptionally alert for the most alarmist findings possible and are willing to elevate them to prominence irrespective of their plausibility. Recent studies suggest some horrible disaster is possible. So what? Lots of things are possible. You should reserve space in the summary for the findings that you have the best evidence for, not the ones you think are the most lurid.

Para 5 lines 35-37. You say that US average temperatures have risen by 1.2 °F “over the last few decades.” Can’t you be more precise? Name the start date and end date of your comparison, and if a slight variation on either end would be influential on the comparison you should report that and justify your choice of end dates.

Page 17

Para 7 line 16. In making this projection do you have an explanation why it should be considered “very likely” in light of all the past failed predictions of an ice-free summer in the Arctic?

Para 8 lines 21—27. National Hurricane Center going back to the 1800’s data clearly indicate a drop in the decadal rate of US landfalling hurricanes since the 1960s. The current decade is on the low end of hurricane frequency even with last summer’s busy season. Yet you don’t mention this, instead you spin the topic to make it sound like the trends are all towards more cyclone activity. This paragraph is one-sided and misleading.

Para 9 lines 29—36. The opening sentence makes an assertion about past observations, then purports to substantiate it with reference to model projections about the future rather than historical data. The next sentence, by referring to large increases in flooding frequency for “several” communities sounds like cherry-picking. Does “several” mean three or four out of a thousand? And has there been *less* flooding in “several” places as well?

Paragraph 10. Regarding “self-reinforcing cycles within the climate system”, in Paragraph 1 your argument depends on the claim that natural variability is known to be minimal on all time scales because it doesn’t manifest itself in climate models, *therefore* modern warming can only be anthropogenic. Yet in this paragraph you claim the climate is prone to large, persistent natural swings that models can’t reproduce, which contradicts your earlier claim. You state that models have a “systematic tendency to underestimate temperature change during past warm periods” which obviously implies that they could systematically underestimate natural warming during the present period as well; yet nine paragraphs earlier your assertion required you to assume this could not be the case. You can’t have it both ways.

You treat the failure of models to reproduce past warming as evidence that future anthropogenic warming may be worse than expected. But if models could be made to account for past variability through improvements that yield a greater tendency to exhibit natural warming trends, it might require a revision of the attribution of modern warming in such a way as to imply a lower greenhouse gas sensitivity, which would imply that future (anthropogenic) warming will be less than currently expected. In other words, the information in this paragraph can support two opposite conclusions. By emphasising only one you exhibit bias.

I can’t suggest how to reword this paragraph. It is likely true that models suppress natural variability in order to prevent drift and low-frequency instability (see, for instance, the discussion in Bereiter et al. Nature 2018 about the inability of climate models to reproduce the large swings in the Younger Dryas event). But acknowledging that fact will require you to acknowledge the weakness of your attribution arguments, which presuppose that GCMs provide a valid representation of natural variability on all time scales.

Page 19 ff.

Paragraphs 1-12: If these claims were true then how is it that the US has grown so prosperous since the 1900s? You have just finished stating that massive, historically unprecedented climate changes occurred in the past century, especially in the past few decades. It is a matter of historical record that throughout this period the quality of life in the US just kept going up and up. Now you say that the next increment of warming will be completely different and will lead to ruin across the land. No exceptions, no caveats, no qualifications: you are asking the reader to forget the pattern that held up to now and take your word for it that disaster is coming. If you really believe that, then you owe it to the readers to be convincing, not cartoonish and apocalyptic. As one example, the opening phrase “cascading disruptions and damages in interdependent networks of infrastructure, ecosystems and social systems” reads like a Hollywood disaster flick—i.e. fiction. You have a very evocative style, but it sets a tone at odds with the expectation that this is a serious scientific document.

Additionally, you are making unsupported assumptions about the costs and benefits of policy. You say that (paragraph 2) “without efforts to reduce carbon emissions and adapt to climate impacts, climate change is projected to cause substantial damage to the U.S. economy.” But the models that tell you this also tell you that *with* efforts to reduce carbon emissions, climate change is projected to cause substantial damage to the U.S. economy: in other words, the policy measures will not prevent or even mitigate the damages. So, you should not refer to them as if their enactment would make any difference. The only policy measures that would appreciably change the warming trajectory involve very extreme reductions in carbon emissions that, on any mainstream reckoning, would cost far more than the value of the avoided damages. If you are prepared to point that out then you can discuss policy, but otherwise stick to the science.

Chapter 1: Overview

Sct. 1.1

Page 24 line 3: How do you know that the climate is changing faster than at any point in human history? Ocean temperature data goes back a couple of decades and only measures the top layers. Tropospheric temperature records go back to 1958. Land surface records go back to the late 1800s, but quality is poor in most regions especially prior to WWII. Human history goes back 10,000 years or more. You are making statements you cannot possibly know to be true.

Page 25 lines 15—18 You say that while the American economy has continued to grow and “some measures of human well-being have improved over the past several decades,” many communities, ecosystems, and economic sectors have already experienced negative impacts and they remain at great risk as warming trends continue. *Some* measures have improved? Can you name any important measures that haven’t, especially in the US? In this sentence you are asking people to believe that the extraordinary technological, scientific and economic advances of the past several decades are at best moderate and debatable, whereas the damages from climate change have already swamped them and will make everything worse in the future. What I take away from it is that the authors are not very good at measuring economic and social welfare, and they have little insight into the things that matter to people when they assess their standard of living.

Sct. 1.2

Page 30 lines 1—2. You claim that natural factors cannot explain the observed rapid changes. Yet a few pages earlier (p. 17 para 10) you said that models underestimate natural variability. If you cannot explain the mechanisms and dimensions of natural variability how can you say that it doesn't account for recent changes? I'm not asserting that it does, I am just reiterating the point that you keep making unqualified assertions about things you do not actually know to be true. Your language needs to reflect the actual state of knowledge and a realistic assessment of your own uncertainty.

Page 30 lines 11—16. It is misleading to say "No combination of natural factors is found in the observational record that would account for the current warming trend." You are referring to Figure 1.2 which does not show *observations* (except for the pink line), it shows model-generated outputs. You can claim that this model decomposes observed changes in such-and-such a way based on the way forcings are represented in the model and the way natural variability is represented, and that this decomposition implies that greenhouse gases play such-and-such a role. But you should acknowledge that the validity of the decomposition rests on the assumed validity of the climate model. You cannot claim that the colored lines are "observational" because they are not. Doing so conflates observation and attribution.

Pages 31-32 Figure 1.2. Why does the red shading end 7 years before the black line?

You are placing a great deal of weight on this diagram which is a very weak form of argumentation. While it is a superficially persuasive picture, there are at least three problems with the argument.

First, you have assumed that the models are accurate representations of climate processes, which is an unsafe assumption. There is a large literature on climate model testing which you have completely ignored. A recent example is Beenstock, Reingewertz and Paldor (2016) "Testing the historical tracking of climate models" *International Journal of Forecasting* <http://www.sciencedirect.com/science/article/pii/S016920701630053X>. This paper points out that if a model's match to target observations is genuine rather than spurious, hindcast errors must be stationary and exhibit a mean-reversion property. But the difference between climate model estimates of the global mean surface temperature and the observed GMST values (from GISS) is in all cases nonstationary and non-mean reverting. That paper also reviews related literature on this question from a variety of authors applying a variety of methods, with the recurring result that climate models fail to reproduce key statistical features of target observations, which means they are not suitable as forecasting tools. The implication is that you cannot boast about how good your models are when the expert modeling literature has shown that they have systematic problems reproducing essential properties of the target variables.

Another important study in this regard is Swanson, K.L., 2013. Emerging selection bias in large-scale climate change simulations. *Geophysical Research Letters*, 40, DOI: 10.1002/grl.50562, which shows that between CMIP3 and CMIP5, GCMs became more like each other but less like the observations. That they no longer overlap with key metrics of surface temperature trends and temperature extremes, and to the extent they yield improved fit with some metrics (like Arctic temperatures) they are likely getting that metric right for the wrong reasons.

Second, the corresponding Figure would fail dramatically in the lower and mid-troposphere, even though the influence of GHGs is supposedly amplified there. We know this because the figure showing it is in IPCC 2013 Ch 10 Fig 10SM.1 (see http://ipcc.ch/pdf/assessment-report/ar5/wg1/supplementary/WG1AR5_Ch10SM_FINAL.pdf). The same sort of decomposition is shown as in your Figure 1.2, except in more detail by showing vertical layers by latitude band. In most cases the observational line rests outside (i.e. below) the GHG-only and combined forcings range and within the “no-GHG forcing” (i.e. natural forcing only) model range. In other words, it shows the opposite of what your figure shows: the models can only reproduce the observed trends by assuming *no* GHG forcing. The only place where the observations and the anthropogenic forcing trends line up is at the surface in the northern mid-latitudes, which is the dominant contributor to the GISS surface record that you use. In the tropics the observations line up with the no-forcing runs from the surface all the way to the top of the troposphere. Globally (60S to 60N) the observations run below the GHG-only and the combined anthropogenic+natural forcings from the surface up to about 8 km.

Third, your decomposition relies on the assumption that natural variability is extremely small, but you have already admitted elsewhere (page 17 para. 10) that models understate natural variability. And we know this fact already from other sources.

The best that can be said of Figure 1.2 is that it is a suggestive argument, but not without serious problems. Unfortunately, you do not inform readers of what these problems are and you vastly overstate its meaning and strength.

Page 39 lines 1—4

You say: “Climate models have proven remarkably accurate in projecting and evaluating the climate change we’ve experienced to date, particularly in the past 60 years or so, when we have greater confidence in the observations (see Figure 1.1).” This is promotional hype. You provide no evidence of the “remarkable accuracy” of climate models, and ignore the many publications showing how bad they are. For example:

Koutsoyiannis, D., A. Efstratadis, N. Namassis and A. Christofides (2008) “On the credibility of climate predictions” *Hydrological Sciences*, 53(4) August 2008

Anagnostopoulos, G. G., D. Koutsoyiannis, A. Christofides, A. Efstratiadis & N. Mamassis (2010). “A comparison of local and aggregated climate model outputs with observed data.” *Hydrological Sciences Journal*, 55(7) 2010.

Fildes, Robert and Nikolaos Kourentzes (2011) “Validation and Forecasting Accuracy in Models of Climate Change” *International Journal of Forecasting* 27 968-995.

McKittrick, Ross R. and Lise Tole (2012) Evaluating Explanatory Models of the Spatial Pattern of Surface Climate Trends using Model Selection and Bayesian Averaging Methods. *Climate Dynamics*, DOI 10.1007/s00382-012-1418-9.

Koutsoyiannis et al. (2008) and Anagnostopoulos et al. (2010) compared long term (100-year) temperature and precipitation trends in a total of 55 locations around the world to model projections. The models performed quite poorly at the annual level, but they also did poorly even when averaged up to the 30-year scale, even though you say this is the level GCMs work best at. They also did no better over larger and larger regional scales. The

authors concluded that there is no basis for the claim that climate models are well-suited for long term predictions over large regions.

Fildes et al. (2011) took the same data set and compared model predictions against a “random walk” alternative, consisting simply of using the last period’s value in each location as the forecast for the next period’s value in that location. The test measures the sum of errors relative to the random walk. A perfect model gets a score of zero, meaning it made no errors. A model that does no better than a random walk gets a score of 1. A model receiving a score above 1 did worse than uninformed guesses. Simple statistical forecast models that have no climatology or physics in them typically got scores between 0.8 and 1, indicating slight improvements on the random walk, though in some cases their scores went as high as 1.8. The CMIP3 climate models got scores ranging from 2.4 to 3.7, indicating a complete failure to provide valid forecast information at the regional level, even on long time scales. The authors commented: “This implies that the current [climate] models are ill-suited to localised decadal predictions, even though they are used as inputs for policy making.”

McKittrick and Tole (2012) created several statistical models that tested the ability of CMIP3 models to explain the spatial pattern of temperature trends over land in comparison with observations of patterns of changes in socioeconomic variables, such as Gross Domestic Product and population. The IPCC explicitly claims socioeconomic do not affect surface temperature records as this would imply non-climatic contamination from processes like urban heat islands, which they claim have been removed from the raw data. 10 of the 22 climate models predicted a spatial pattern of trends that was negatively correlated with observations. In 10 other cases they found the climate models predicted a pattern that was loosely correlated with observations, but not significantly so—in other words not significantly better than random numbers. In only 2 cases was there statistically significant evidence of explanatory power.

I also mentioned Beenstock et al. (*Int’l J. Forecasting* 2016) and Bereiter et al. (*Nature* 2018) above.

Your claim about the “remarkable accuracy” of GCMs needs to be set in the context of how models are tuned. Since models are coerced to match the past, this degree of fit cannot be used as evidence of forecasting ability. The IPCC AR5 Ch 9 (p. 18) points out:

The approach to model evaluation taken in [this] Chapter reflects the need for climate models to represent the observed behaviour of past climate as a necessary condition to be considered a viable tool for future projections. This does not, however, provide an answer to the much more difficult question of determining how well a model must agree with observations before projections made with it can be deemed reliable. Since the AR4, there are a few examples of emergent constraints where observations are used to constrain multi-model ensemble projections. These examples, which are further discussed in Section 9.8.3, remain part of an area of active and as yet inconclusive research.

And on page 75:

[Many] studies have failed to find strong relationships between observables and projections. Whetton et al. (2007) and Knutti et al. (2010a) found that correlations between local to regional climatological values and projected changes are small except for a few regions. Scherrer (2011) finds no robust relationship between the ability of the CMIP3 models to represent interannual variability of near surface air temperature and the amplitude of future

warming. Raisanen et al. (2010) report only small (10–20%) reductions in cross-validation error of simulated 21st century temperature changes when weighting the CMIP3 models based on their simulation of the present-day climatology.

By contrast, readers of the NCA4 learn nothing about GCM limitations and are left with a false impression of their usefulness and accuracy.

Page 39 lines 4—8

You say “It’s important to note that climate model projections are, broadly speaking, not designed to directly capture every annual or even decadal variation in a historical record. Rather, since “climate” is defined as weather conditions over multiple decades (for example, over periods of 30 years), climate model projections are aimed more towards capturing long-term changes.”

Then why do you so often focus on short term weather phenomena in this report, such as the 2017 hurricane season? You seem ready to invoke short term weather phenomena when it furnishes examples of “harmful” or “damaging” events, but when short-term events run counter to expectations you dismiss their importance by saying you are only concerned with long term trends.

Page 50 lines 17-18

After listing valuations of impacts (ignoring for a moment that they seem to be tweaked towards the high end), you conclude “Each of these avoided impacts represent domestic economic benefits of mitigation on the order of tens to hundreds of billions of dollars per year.” No they don’t. Domestic mitigation and even global mitigation on a scale like the Kyoto and Paris treaties would not affect the time path of warming. There are no policy proposals on the table that would substantially change the rate of accumulation of GHG’s in the atmosphere.

You need to point out that your figures are, at best, *gross* benefits since you are not taking account of the costs of the policies necessary to achieve the mitigation. Neither are you discounting those benefits to the present, which is important since the impacts warned of in the 1st NCA have unfolded far more slowly than forecast and this will likely be true of your edition as well, meaning the effects of GHG emissions won’t be incurred until a century or more down the road. Hence the discounted gross benefits you describe are tiny and far in the future, and (to put them in perspective) are dwarfed many times over by recent annual variations in the US federal budget deficit, and stock market fluctuations.

From: John Christy <climateman60@gmail.com>
Sent: Monday, June 23, 2025 1:31 PM
To: Steven Koonin
Cc: Ross McKittrick; Judith Curry; Travis Fisher; Roy Spencer; Josh Loucks; Seth Cohen
Subject: Re: Summary chapter

Steve

This point refers to more submissions than just mine. I have some back at the office, including one by Ross. I'll take a look at those Friday to see how "credible" they are.

I mention this because overall, the NASEM review was pathetic, but other reviewers pointed out glaring weaknesses of 3OD. The NASEM review was a gift to NCA5, not a critical analysis by experts. At some point, perhaps DoE might want to make an observation (completely separate from our efforts here through channels they know) that the NASEM review team was light on climate science expertise - as was the authorship of the NCA5.

John C.

Sent from my iPhone

On Jun 23, 2025, at 2:33 AM, Steven Koonin <steven.koonin@gmail.com> wrote:

John- Does your point refer only to your comments or have you done a sampling of NASEM's and others comments?

SEK

From: John Christy <climateman60@gmail.com>
Sent: Sunday, June 22, 2025 8:34 PM
To: Ross McKittrick <ross.mckittrick@gmail.com>
Cc: Steve Koonin <steven.koonin@gmail.com>; Judith Curry <curry.judith@gmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>; Roy Spencer <roywspencer@hotmail.com>; Josh Loucks <loucksj14@gmail.com>; Seth Cohen <seth.cohen@hq.doe.gov>
Subject: Re: Summary chapter

Judy

Attached is the NASEM review.

Steve/Ross (not sure who is holding the Master)

After reading my public comments to the NCA5 3rd order draft, would it not be correct to say on page 3,

- The NCA5 authors failed to adopt some improvements recommended by NASEM and failed to address many credible public comments.

John C.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
climateman60@gmail.com

From: Roy Spencer <roywspencer@hotmail.com>
Sent: Monday, June 23, 2025 9:19 AM
To: Steven Koonin; 'Ross McKitrick'; 'John Christy'
Cc: 'Judith Curry'; 'Travis Fisher'; 'Josh Loucks'; 'Seth Cohen'
Subject: Re: Summary chapter

Change "ad hoc time scales" to "short periods" in the executive summary?

-Roy

From: Steven Koonin <steven.koonin@gmail.com>
Sent: Monday, June 23, 2025 7:20 AM
To: 'Ross McKitrick' <ross.mckitrick@gmail.com>; 'John Christy' <climateman60@gmail.com>
Cc: 'Judith Curry' <curry.judith@gmail.com>; 'Travis Fisher' <travis.scott.fisher@gmail.com>; 'Roy Spencer' <roywspencer@hotmail.com>; 'Josh Loucks' <loucksj14@gmail.com>; 'Seth Cohen' <seth.cohen@hq.doe.gov>
Subject: RE: Summary chapter

My minor edits on Chapter 8 indicated. I think this is good to go. Now just need to work on Judy's draft of Chapter 7.

I will be scarce (but not entirely off line) from now until Sunday afternoon, off with kids/grandkids to Sea Island GA marking our 50th wedding anniversary.

SEK

From: Ross McKitrick <ross.mckitrick@gmail.com>
Sent: Sunday, June 22, 2025 3:10 PM
To: John Christy <climateman60@gmail.com>
Cc: Steven Koonin <steven.koonin@gmail.com>; Judith Curry <curry.judith@gmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>; Roy Spencer <roywspencer@hotmail.com>; Josh Loucks <loucksj14@gmail.com>; Seth Cohen <seth.cohen@hq.doe.gov>
Subject: Re: Summary chapter

Here are my edits to the conclusion chapter, highlighted in cyan to stand out. There were a few places where I thought we need to state the conclusions a bit more clearly. I've added a query about the term 'hazard'. I haven't looked at Ch 7 yet but will try to add to it tomorrow.

On Sun, Jun 22, 2025 at 12:33 PM John Christy <climateman60@gmail.com> wrote:

Steve

I'm trying to handle this from my phone, so a little rough. Your red-letter question about NCA's incorporation of alternative views is no problem. I have a few of the public comment submissions that were ignored, including separate submissions by Ross and myself. When I'm back in the office, I can find those. I'm wondering if we can find any information on NCA5's response to our submissions?

It may be enlightening to add the phrase after your point about ignoring comments (I can't remember your exact words), "including public comment submissions by two CWG25 authors"

John C.

Sent from my iPhone

On Jun 22, 2025, at 6:42 AM, Steven Koonin <steven.koonin@gmail.com> wrote:

I've now built on Judy's summary chapter 8, rationalizing it with Section 1.3. Note particularly the recommendations for NCA6.

Also made a start on Chapter 7.

Both are included in the integrated draft attached, which you are urged to read/comment/edit.

SEK

From: Judith Curry <curry.judith@gmail.com>

Sent: Saturday, June 21, 2025 10:32 AM

To: Steven Koonin <steven.koonin@gmail.com>

Cc: Travis Fisher <travis.scott.fisher@gmail.com>; Roy Spencer <roywspencer@hotmail.com>; Ross McKittrick <ross.mckittrick@gmail.com>; John Christy <climateman60@gmail.com>; Josh Loucks <loucksj14@gmail.com>; Cohen, Seth <seth.cohen@hq.doe.gov>

Subject: Summary chapter

Draft of summary chapter is attached, with short recommendations section (cleaned up from yesterday's version). I look forward to your feedback

Below is the recommendations section that I came up with, I'm sure this will be controversial but it will at least trigger the group thinking about the issue:

Recommendations

In view of the substantial problems with NCA5 in failing to comply with the USGCRP mandate and the tenets of Gold Standard Science, along with the endemic bias in the climate community towards alarmism and policy advocacy on the issue of climate change, we do not see a clear path forward for the NCA6 at this time.

The USGCRP mandate to the NCA should be revisited. The current mandate is vague and off point, and it is not entirely surprising that successive NCA teams have interpreted the mandate differently. With regards to specific wording in the mandate, the term "global change" is ambiguous and outdated; it is no longer used in most climate-related documents. It is becoming increasingly clear that climate models are not fit-for-purpose for making regional projections 25 and 100 years in advance.

There are three fundamental issues to be addressed in the near term to support the USGCRP and federal policy making:

- Review of climate science (we suggest that the CWG25 Report meets this objective)
- Comprehensive risk assessment of extreme weather and climate events
- Evaluation of USGCRP portfolio of funded projects and recommendations for the future.

SOMETHING ABOUT ENERGY POLICY???

Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
<~WRD2957.jpg> curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

<01.NCA5.Review.June20[JC][SEK].docx>

From: Steven Koonin <steven.koonin@gmail.com>
Sent: Monday, June 23, 2025 8:21 AM
To: 'Ross McKittrick'; 'John Christy'
Cc: 'Judith Curry'; 'Travis Fisher'; 'Roy Spencer'; 'Josh Loucks'; 'Seth Cohen'
Subject: RE: Summary chapter
Attachments: 01.NCA5.Review.June20[JC][SEK][JCurry][RM][SEK].docx

My minor edits on Chapter 8 indicated. I think this is good to go. Now just need to work on Judy's draft of Chapter 7.

I will be scarce (but not entirely off line) from now until Sunday afternoon, off with kids/grandkids to Sea Island GA marking our 50th wedding anniversary.

SEK

From: Ross McKittrick <ross.mckittrick@gmail.com>
Sent: Sunday, June 22, 2025 3:10 PM
To: John Christy <climateman60@gmail.com>
Cc: Steven Koonin <steven.koonin@gmail.com>; Judith Curry <curry.judith@gmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>; Roy Spencer <roywspencer@hotmail.com>; Josh Loucks <loucksj14@gmail.com>; Seth Cohen <seth.cohen@hq.doe.gov>
Subject: Re: Summary chapter

Here are my edits to the conclusion chapter, **highlighted in cyan to stand out**. There were a few places where I thought we need to state the conclusions a bit more clearly. I've added a query about the term 'hazard'. I haven't looked at Ch 7 yet but will try to add to it tomorrow.

On Sun, Jun 22, 2025 at 12:33 PM John Christy <climateman60@gmail.com> wrote:

Steve

I'm trying to handle this from my phone, so a little rough. Your red-letter question about NCA's incorporation of alternative views is no problem. I have a few of the public comment submissions that were ignored, including separate submissions by Ross and myself. When I'm back in the office, I can find those. I'm wondering if we can find any information on NCA's response to our submissions?

It may be enlightening to add the phrase after your point about ignoring comments (I can't remember your exact words), "including public comment submissions by two CWG25 authors"

John C.

Sent from my iPhone

On Jun 22, 2025, at 6:42 AM, Steven Koonin <steven.koonin@gmail.com> wrote:

I've now built on Judy's summary chapter 8, rationalizing it with Section 1.3. Note particularly the recommendations for NCA6.

Also made a start on Chapter 7.

Both are included in the integrated draft attached, which you are urged to read/comment/edit.

SEK

From: Judith Curry <curry.judith@gmail.com>
Sent: Saturday, June 21, 2025 10:32 AM
To: Steven Koonin <steven.koonin@gmail.com>
Cc: Travis Fisher <travis.scott.fisher@gmail.com>; Roy Spencer <roywspencer@hotmail.com>; Ross McKittrick <ross.mckittrick@gmail.com>; John Christy <climateman60@gmail.com>; Josh Loucks <loucksj14@gmail.com>; Cohen, Seth <seth.cohen@hq.doe.gov>
Subject: Summary chapter

Draft of summary chapter is attached, with short recommendations section (cleaned up from yesterday's version). I look forward to your feedback

Below is the recommendations section that I came up with, I'm sure this will be controversial but it will at least trigger the group thinking about the issue:

Recommendations

In view of the substantial problems with NCA5 in failing to comply with the UCGCRP mandate and the tenets of Gold Standard Science, along with the endemic bias in the climate community towards alarmism and policy advocacy on the issue of climate change, we do not see a clear path forward for the NCA6 at this time.

The USGCRP mandate to the NCA should be revisited. The current mandate is vague and off point, and it is not entirely surprising that successive NCA teams have interpreted the mandate differently. With regards to specific wording in the mandate, the term “global change” is ambiguous and outdated; it is no longer used in most climate-related documents. It is becoming increasingly clear that climate models are not fit-for-purpose for making regional projections 25 and 100 years in advance.

There are three fundamental issues to be addressed in the near term to support the USGCRP and federal policy making:

- Review of climate science (we suggest that the CWG25 Report meets this objective)
- Comprehensive risk assessment of extreme weather and climate events
- Evaluation of USGCRP portfolio of funded projects and recommendations for the future.

SOMETHING ABOUT ENERGY POLICY???

<~WRD2957.jpg> Judith Curry, President
CFAN - Climate Forecast Applications Network
Reno, NV USA
curry.judith@cfanclimate.com | +1.404.803.2012
<http://www.cfanclimate.net>

<01.NCA5.Review.June20[JC][SEK].docx>

Review of the Fifth National Climate Assessment

EXECUTIVE SUMMARY	3
1 INTRODUCTION	4
1.1 ABOUT THIS REPORT	4
1.2 ABOUT THE NATIONAL CLIMATE ASSESSMENTS	4
1.3 STANDARDS FOR ASSESSING NCA PRODUCTS	5
1.4 WHEN PEER REVIEW FAILS	6
2 NCA5 OVERVIEW CHAPTER: HYPERBOLIC ADVOCACY LANGUAGE AND UNSCIENTIFIC TONE.....	9
3 OVERCONFIDENCE WHEN STATING CONCLUSIONS	11
3.1 INFLATED CERTAINTY LEVELS	11
3.2 OVERSTATING FINDINGS IN UNDERLYING SOURCES	12
3.3 TECHNICAL EXAMPLE: EMERGENT CONSTRAINTS	13
4 RELIANCE ON SHORT TIME PERIODS FOR TREND ANALYSIS.....	14
4.1 AVERAGE AND EXTREME PRECIPITATION.....	14
4.2 HEATWAVES.....	15
5 INADEQUATE TRACEABLE ACCOUNTS.....	18
6 OVEREMPHASIS ON EXTREME SCENARIOS	20
7 CONFLATION OF NATURAL AND ANTHROPOGENIC CLIMATE CHANGES	22
8 SUMMARY EVALUATION OF NCA5 AND RECOMMENDATIONS FOR NCA6.....	24
8.1 COMPLIANCE WITH USGCRP’S STATUTORY OBLIGATION	24
8.2 ADHERENCE TO THE TENETS OF GOLD STANDARD SCIENCE	25
8.3 SUITABILITY FOR INFORMING FEDERAL CLIMATE AND ENERGY POLICY	25
8.4 RECOMMENDATIONS FOR NCA6.....	26
9 REFERENCES	27
APPENDICES.....	29
APPENDIX 1: CHARGE TO THE REVIEW	29
APPENDIX 2: REPRODUCIBILITY OF NCA5 CLAIM OF EXTREME PRECIPITATION TRENDS	30
ABOUT THE AUTHORS.....	35

EXECUTIVE SUMMARY

This report critically evaluates the Fifth National Climate Assessment (NCA5), finding it an inadequate basis for climate and energy policies. A detailed review of the foundational chapters on climate science raises several key concerns:

Scientific Integrity

- An advocacy tone, particularly in the Overview chapter, inconsistent with scientific objectivity
- An endemic overconfidence when stating conclusions, including inflated certainty levels and overstatement of findings from underlying sources

Flawed methodology

- Use of *ad hoc* time scales for trend analyses in areas such as precipitation and heatwaves
- An overemphasis on extreme scenarios for future emissions
- Inadequate traceable accounts to support key conclusions

Deficient Review Process

- A review by the National Academy of Sciences, Engineering, and Medicine (NASEM) failed to challenge some fundamental flaws in NCA5
- The NCA5 authors failed to adopt some improvements recommended by NASEM

The report shows NCA5 to be a biased and incomplete picture of climate science that skews toward excessive climate risk. Consequently, NCA5 should not be used as basis for climate and energy policies.

1 INTRODUCTION

1.1 About this Report

This report responds to a request from OSTP Director Michael Kratsios (reproduced in Appendix 1) that we assess the suitability of the Fifth National Climate Assessment (NCA5 2023) for informing climate and energy policies.

To conduct this assessment we reviewed NCA5 itself, the National Academies of Science, Engineering and Medicine (NASEM) review of the Third Order Draft, and the USGCRP responses to that review. We have drawn upon our long experience working on advisory reports, including for the NASEM, the Intergovernmental Panel on Climate Change (IPCC) and other organizations, as writers, reviewers and study leaders.

We find that NCA5 should not be relied on for policy making as it is an incomplete and misleading picture of our understanding of the changing climate and the risks it poses to the nation. NCA5 was selective and incomplete in its survey of climate science as of its publication in 2023 and has become even more so in the years since. We have reviewed many key scientific developments in a separate report to Energy Secretary Wright (Climate Working Group 2025, herein denoted “CWG25”). The overall effect of the biases and omissions of NCA5 is an excessively dire picture of climate risk.

To support our finding, the following sections of this chapter provide some background on the National Climate Assessments and the standards by which we have assessed NCA5. Chapters 2 through 6 detail important ways in which NCA5 fails to meet those standards. Chapter 7 then follows with an assessment of the NASEM review. Finally, Chapter 8 summarizes our evaluation of NCA5.

1.2 About the National Climate Assessments

The U.S. Global Change Research Program (USGCRP) was established by Presidential Initiative in 1989 and mandated by Congress in the Global Change Research Act (GCRA) of 1990 to develop and coordinate “a comprehensive and integrated United States research program which will assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change.”

The National Climate Assessment (NCA) Reports evolved from the GCRA requirement to

Prepare and submit to the President and the Congress an assessment which (1) integrates, evaluates, and interprets the findings of the Program and discusses the scientific uncertainties associated with such findings; (2) analyzes the effects of global change on the natural environment, agriculture, energy production and use, land and water resources, transportation, human health and welfare, human social systems, and biological diversity; and (3) analyzes current trends in global change, both human-induced and natural, and projects major trends for the subsequent 25 to 100 years.

The five NCA Reports to date have interpreted this mandate in different ways:

- NCA1 (2000) was a multidisciplinary effort to study and portray in regional detail the potential effects of human-induced global warming on the United States.
- NCA2 (2009) was a relatively short report that not only focused on the potential consequences of climate change but also sought to identify potential adaptation measures and identify the highest priorities for future research.

- NCA3 (2014) was an expanded effort that continued along the lines of NCA2, and was distinguished by a comprehensive review process, including a review by the National Academy of Sciences. NCA3 introduced a traceability analysis for each key finding, including a description of uncertainties.
- NCA4 (2017/2018) was a further expanded effort published in two volumes: I Climate Science Special Report, and II Impacts, Risk, and Adaptation in the United States. This was the first NCA report to devote significant effort to assessing climate science.
- NCA5 (2023) returned to a single volume format, reducing discussion of climate science to a cursory two chapters, with continuing with a focus on regional and sectoral impacts of climate change. NCA5 expanded its remit to topics that are arguably outside the purview of the USGCRP, focusing on “Climate Action” and policy recommendations with a social justice emphasis. NCA5’s self-description is reproduced as Appendix II.

These successive interpretations of the NCA are poorly aligned with the GCRA’s statutory requirements. Only NCA4 gives serious consideration to climate science, which receives the great majority of USGCRP funding, and even then misrepresents some important points (Section 1.4 below offers an example). Natural climate variability is essentially dismissed as unimportant in NCA4 and barely mentioned in NCA5 in most contexts, despite the mandate to include both human-caused and natural climate change. Most significantly, NCA5 has redirected the focus away from climate science and even the hazard elements of impacts, towards evaluation of societal vulnerabilities and advocacy for particular policy options, especially wind and solar power. The cover image for the NCA5 Report is the installation of a solar panel.

1.3 Standards for Assessing NCA Products

Beyond the statutory requirements stated above, another pertinent standard is President Trump’s executive order of May 23, 2025, Restoring Gold Standard Science. It enumerates some of the characteristics of good science:

- i. reproducible;
- ii. transparent;
- iii. communicative of error and uncertainty;
- iv. collaborative and interdisciplinary;
- v. skeptical of its findings and assumptions;
- vi. structured for falsifiability of hypotheses;
- vii. subject to unbiased peer review;
- viii. accepting of negative results as positive outcomes; and
- ix. without conflicts of interest.

Although these should be self-evident to those trained in science, it is surprising that some scientists have found them controversial (Dellawalla et al. 2025).

Good climate and energy policies should balance the risks and benefits of a changing climate against the world’s growing demand for reliable and affordable energy. To strike that balance, policymakers must understand at least two complex and nuanced topics: the certainties and uncertainties of climate science and the technoeconomic realities of energy systems. Experts in those subjects have a responsibility to communicate their understanding to non-experts clearly, completely, and without bias.

Expertise in energy systems resides largely in the private sector, where it is essential to providing the reliable and affordable energy services that are the lifeblood of society. Understanding is therefore continually refined and tested by operational demands and the discipline of the marketplace. In contrast, climate science expertise is found largely in the non-profit realm of universities and government laboratories and so has a more academic character, with greater uncertainties and hence need for expert judgement.

For those reasons, assessments of climate science that will be influential for policy making must include statements about the strength of knowledge. The IPCC's approach to assessing strength of knowledge is based on judgment of the available evidence and agreement among experts. But there are more sophisticated knowledge characterizations for risk management (Aven 2017). Here are its elements:

- The degree to which the assumptions made are reasonable/realistic based on background knowledge
- The degree to which data/information exists and are reliable and relevant
- The degree to which there is disagreement among experts (including those from different environments or academic fields)
- The degree to which the phenomena involved are understood and accurate models exist
- The degree to which the knowledge has been thoroughly examined with respect to unknown knowns

1.4 When Peer Review Fails

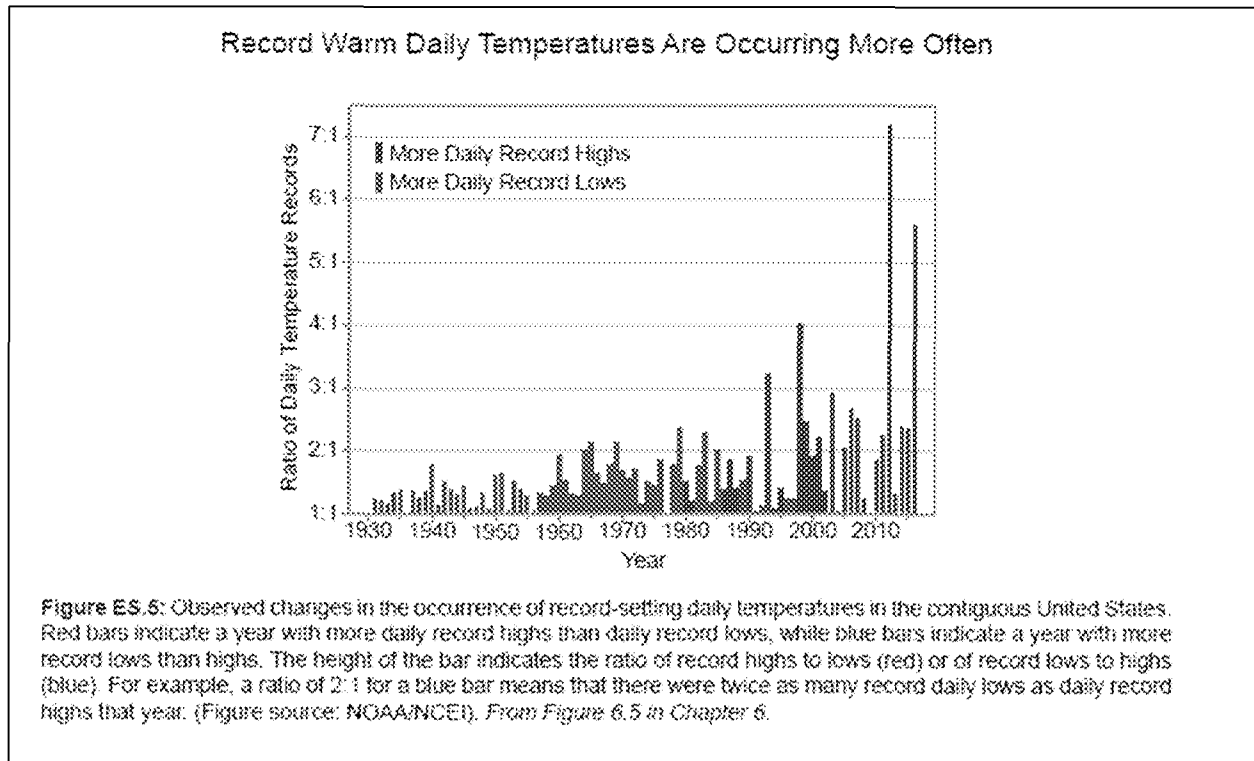
Peer review of reports like IPCC and NCA products is not a silver bullet that guarantees quality. The peer review process for these reports differs in some important respects from traditional peer review in academic journals. First, during the open review phases of early NCA drafts reviewers are volunteers who self-select what parts of the report to read, whereas the editors of academic journals recruit reviewers with relevant expertise and assign them to specific papers. As a result, there is no guarantee at that stage that any particular section of an NCA report was reviewed by anyone, let alone by someone with a perspective that differs from the authors. In fact, many potential reviewers have given up over the years because their input has systematically been ignored. The introduction of a NASEM review stage is at best a partial remedy for this. However, NCA authors have near complete authority whether to accept or reject review comments. By contrast, the Editor of an academic journal mandates the author to respond, and the reviewer and Editor assess its adequacy. Finally, the work of an NCA chapter author team is guaranteed to be published, whereas academic journals routinely reject papers that do not pass review.

These points are important to bear in mind because some readers might dismiss any criticism of NCA products out of hand on the grounds that they were "peer reviewed". But the test of a report is whether its contents are a valid representation of the available evidence. Here we give an example in which NCA4 gave prominence to a figure that completely misrepresented the underlying data and which evaded peer review to do so. Further details can be found in Koonin (2024).

As shown in CWG25 Section 6.3 the number of heat extremes in the U.S. peaked in the 1930s and has declined ever since. Considering cold and hot extremes together the U.S. the U.S. climate has become more moderate over time. NCA4's Part I says (prominently and with *Very High Confidence*) on Page 19 of the Executive Summary:

There have been marked changes in temperature extremes across the contiguous United States. The number of high temperature records set in the past two decades far exceeds the number of low temperature records.

and offers this figure in support:

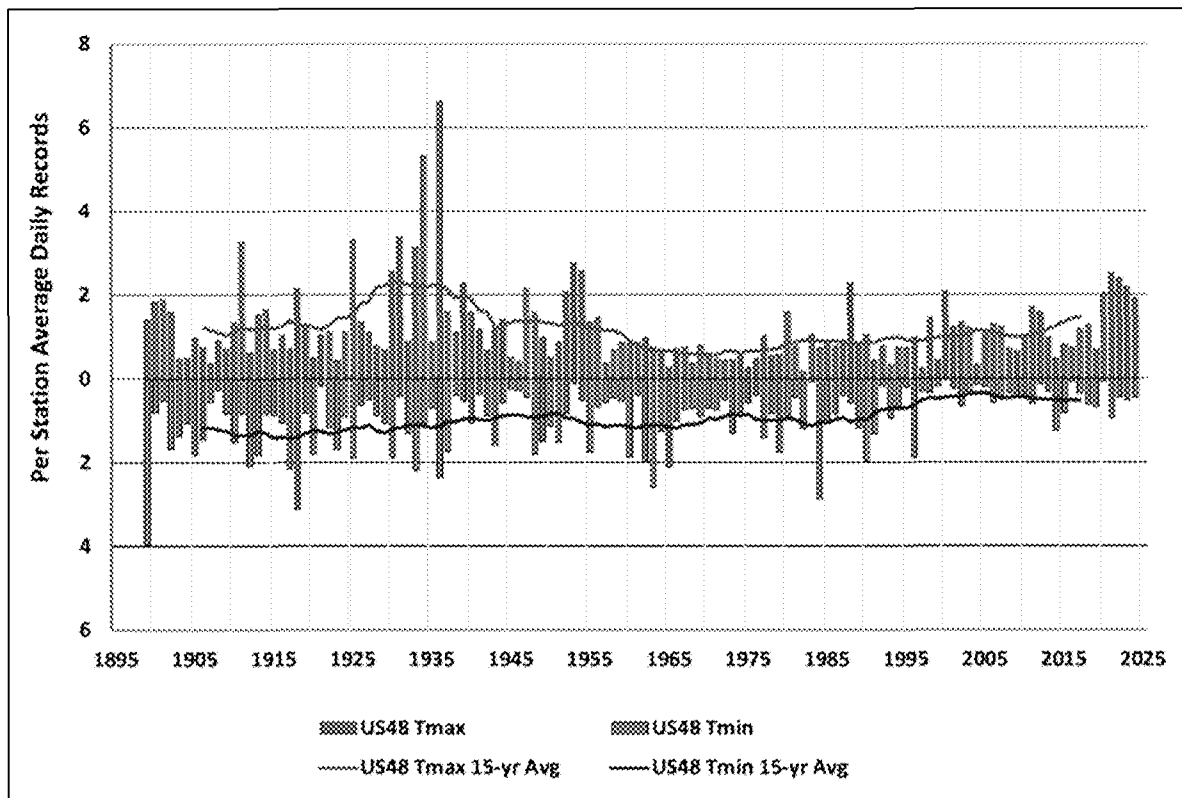


The figure appears to validate the claim that record warm daily temperatures are occurring more often. But the underlying data do not. Rather, they show that extreme heat in the U.S. peaked in the 1920s and 1930s and declined thereafter, as supported by Figure 6.4 deep within the CSSR itself (reproduced in our Section 4.2 below).

Figure ES.5 does not even show what its title implies, as it displays not simple counts of cold and warm extreme events, but rather ratios of the two counts. In fact, both types of extremes declined over the sample interval, but cold events declined more than warm events, so the ratio of warm extremes to cold extremes increased. By graphing the ratio instead of counts, NCA4 creates a visual impression opposite to what is in the data.

Figure 6.3.3 of CWG25 (reproduced below) shows the results of a proper analysis of the data – defining each record as the singular extreme in the sample interval, displaying numbers of warm and cold records separately, and beginning the analysis in 1899 rather than 1930. It makes evident the exceptional heat of the 1920s and especially the 1930s, peaking in 1936. The increased heat of the past five years is too brief to be deemed climatically significant and, in any event, occurred after the CSSR was published in 2017. The frequency of cold records has declined, especially over the last quarter of the period in which only 13 percent of the extreme cold events were measured. In contrast,

25 percent of the heat records were achieved in the last quarter, which is consistent with statistical expectations. As a result, the ratio of heat to cold extremes shown in Figure ES.5 of the CSSR explodes in recent decades. The overall reduction in numbers of both cold and hot extremes over the past century indicates a climate *less* prone to extremes, in sharp contrast to the message of NCA4 Figure ES.5.



Number of daily record High (red) and Low (blue) temperatures for warm and cold seasons in the CONUS. The lines represent the 15-year running, centered average. Source: 1,211 USHCN stations supplemented as needed to achieve a minimum of 92 percent of observations in the 126-year period since Dec 1898. US48: contiguous U.S. states. Tmax: maximum temperature. Tmin: minimum temperature. Source: CWG25 Figure 6.3.3.

The National Academies' expert review panel criticized the discussion of temperature extremes in a late draft of the CSSR. In reference to the CSSR's Key Finding 2 of Chapter 6, they said:

Further, it is difficult to understand how a statement that includes increases in extreme warmth can be associated with a high confidence or extremely likely statement, given that most of the graphics in this chapter show a decrease in extreme warmth in the historical record.

The Federal official in charge of the CSSR (Michael Kuperberg, Executive Director of the USGCRP) responded to the Academies' review by noting that

Almost every recommendation from the NAS was incorporated [in the final version]... and a new figure was added on changes in record high and low temperatures

The “new figure” referred to is the Figure ES.5, which did not appear in the draft reviewed by the Academies’ panel. It seems unlikely that the Academies panel ever saw that figure because they surely would have commented if they had and it wouldn’t have survived to publication. And the figure’s problems were evidently not flagged (or were ignored) in the subsequent internal government reviews.

With this background we now present our critique of NCA5.

2 NCA5 OVERVIEW CHAPTER: HYPERBOLIC ADVOCACY LANGUAGE AND UNSCIENTIFIC TONE

NCA5 Chapter 1, “Overview”, holds a prominent place in the Report since it summarizes the entire report and is the only section that many will read. Although the later chapters of NCA5 contain much sound scholarly content, Chapter 1 is marred by an activist tone and language that aggressively promotes mitigation policies. As such, this chapter adds an imprimatur of scientific authority to oversimplified declarations of opinion about public policy. Many examples can be cited; here we note a few that are particularly egregious.

Chapter 1 opens as follows:

The more the planet warms, the greater the impacts. Without rapid and deep reductions in global greenhouse gas emissions from human activities, the risks of accelerating sea level rise, intensifying extreme weather, and other harmful climate impacts will continue to grow. Each additional increment of warming is expected to lead to more damage and greater economic losses compared to previous increments of warming, while the risk of catastrophic or unforeseen consequences also increases.

This statement presupposes that all warming is anthropogenic, that all warming is bad and causes economic damage, and that warming intensifies extreme weather. Such sweeping generalizations go well beyond what science has or can establish. The statement also refers to growing risks without saying whether they were large to begin with -- a small risk that grows may still be a small risk, and a large risk may be only incrementally worsened. A scientifically-sound version of this paragraph would instead say something like the following:

The Earth is warming because of a combination of natural and anthropogenic influences. This warming will generate a mix of benefits and harms that varies by region, to which society should be prepared to adapt. Some types of extreme weather have worsened recently, while others have not changed or have even declined in intensity. Reducing emissions of greenhouse gases might slow the warming although such policies have proven to be costly and disruptive, so any climate actions to be weighed against the potential benefits.

On the next page the Overview states:

Each additional increment of warming leads to greater risks [here it lists 7 key components of society including food security and the economy]... Without deeper cuts in global net emissions, climate risks to the US will continue to grow... Action to limit future warming and reduce risks can have near-term benefits and opportunities: low-carbon energy jobs, Improved air quality, Health benefits, Economic benefits...”

The authors write as if climate policy does not involve trade-offs and all measures to reduce future warming will be effective and beneficial. But the vast body of scholarship on climate science and economics does not support such simplistic claims. Not every additional increment of warming leads to economic harms; in fact, NCA5 Chapter 19 acknowledges that there will also be benefits. Nor is climate policy guaranteed to create jobs or benefit the economy; in many cases it has done the opposite. Such deceit is a disservice to policymakers.

Pages 8 and 9 of the Overview promote renewable energy options by noting, correctly, that the levelized costs of wind/solar generation have fallen sharply since 2010, and so offers this rationale for pursuing deep emission reductions:

Recent growth in the capacities of wind, solar, and battery storage technologies is supported by rapidly falling costs of zero- and low-carbon energy technologies, which can support even deeper emissions reductions. For example, wind and solar energy costs dropped 70% and 90%, respectively, over the last decade, while 80% of new generation capacity in 2020 came from renewable sources.

Yet it has long been known that intermittent renewables generation must be supplemented by dispatchable generation to meet grid reliability standards, and that doing so (e.g., through natural gas, fission, or storage) significantly increases the cost of electricity. Further, there are yet unmet synchronization challenges in transmission grids with heavy penetration of wind and solar power. Here again it is advisory malpractice not to acknowledge these facts.

Page 14 of the Overview presents future emission scenarios with the following description: “Climate modeling experts develop global climate projections for a range of plausible futures.” The word “plausible” is applied to all of the scenarios. The accompanying Figure includes both SSP3-7.0 and SSP5-8.5, the latter reaching the same radiative forcing as RCP8.5. The Figure does not compare observed emissions with previous projections nor does it caution readers that SSP3-7.0 and SSP5-8.5 are extreme worst case scenarios that, like RCP8.5, have been heavily criticized in the scientific literature (CWG25 3.2.1). By describing the entire envelope of emission projections as “plausible” the report opens the door to later presenting impacts associated with extreme and implausible emission scenarios as part of a baseline “business-as-usual” future.

Page 17 of the Overview introduces the discussion of risks from extreme weather events by saying “Harmful impacts from more frequent and severe extremes are increasing across the country.” This creates the impression that disaster losses are driven by trends in extreme weather. While the section goes on to acknowledge that some of the increase is due to increases in the value of assets at risk it then invokes the NOAA Billion Dollar Dataset as evidence of extreme weather getting worse. Scientists have shown that this is an invalid metric (CWG 10.2) since it measures the growth of the economy not the frequency of extreme weather, and indeed NOAA has recently withdrawn the data product (Pielke Jr. 2024, 2025). Even though it was still distributed by NOAA at the time of the NCA5, the report authors should have assessed it skeptically and seen that it was unfit for the purpose of measuring climate trends.

Page 23 of the Overview states, in large font:

Climate changes are making it harder to maintain safe homes and healthy families; reliable public services; a sustainable economy; thriving ecosystems, cultures, and traditions; and strong communities.

It is pointless to try to evaluate this statement on scholarly grounds; it is self-evidently hyperbolic. This kind of language doesn't belong in a scientific assessment report. Its prominent inclusion points not only to the willingness of NCA5 authors to promote alarm, but also the ineffectiveness of the review process in eliminating such statements.

3 OVERCONFIDENCE WHEN STATING CONCLUSIONS

3.1 Inflated certainty levels

Overconfidence in stating conclusions is an endemic problem in NCA5. The authors frequently make sweeping generalizations without appropriate caveats or acknowledging uncertainties. The overconfidence begins with inflated language to describe certainty levels.

NCA5 uses specific terms to convey information about scientific confidence associated with important finds, observations and projections. The Front Matter of NCA5 states that

confidence in a finding is based on the type, amount, quality, strength, and consistency of evidence; the skill, range, and consistency of methods to detect, evaluate, attribute, and interpret climate trends; and the degree of agreement across scientific information sources.

and Table 1 from the Front Matter provides calibrated language for confidence assessment:

Very high:	Strong evidence (established theory, multiple sources, well documented and accepted methods, etc.). High consensus
High:	Moderate evidence (several sources, some consistency, methods vary and/or documentation limited, etc.). Medium consensus
Medium:	Suggestive evidence (a few sources, limited consistency, methods emerging, etc.) Competing schools of thought.
Low:	Inconclusive evidence (limited sources, extrapolations, inconsistent findings, poor documentation and/or methods not tested, etc.). Disagreement or lack of opinions among experts.

This terminology is inflated: *high confidence* with just moderate evidence and medium consensus; *medium confidence* with only suggestive evidence and competing schools of thought. This inflation in terminology leads to overconfidence in conclusions.

Even with this inflated terminology, NCA5 further inflates the confidence level of many of its conclusions to well beyond what the IPCC has concluded with more thorough justification, and also by incorrectly applying its own standards. An example is the conclusion about anthropogenic influence on climate change, arguably one of the most important scientific statements of the report.

Key Message 3.1 Traceable Account states:

There is *very high confidence* that emissions of GHGs from human activities, fossil fuel use in particular, have unequivocally caused *all* global warming observed over the industrial era.

while the corresponding statements from IPCC AR5 and AR6 are

AR5: It is *extremely likely* that *more than half* of the observed increase in global average surface temperature from 1951 to 2010 was caused by the anthropogenic increase in greenhouse gas concentrations and other anthropogenic forcings together.” (IPCC, 2013)

AR6: The *likely* range of total human-caused global surface temperature increase from 1850–1900 to 2010–2019 is 0.8°C to 1.3°C, with a best estimate of 1.07°C. It is *likely* that well-mixed GHGs contributed a warming of 1.0°C to 2.0°C, other human drivers (principally aerosols) contributed a cooling of 0.0°C to 0.8°C, natural drivers changed global surface temperature by –0.1°C to +0.1°C, and internal variability changed it by –0.2°C to +0.2°C. It is *very likely* that well-mixed GHGs were the main driver of tropospheric warming since 1979.

The IPCC AR5 and AR6 statements provide likelihood assessments but not a confidence level. While NCA5 claims with *very high confidence* that fossil fuels have unequivocally caused *all* global warming, AR5 refers to “*more than half* of the observed warming” and AR6 provides a more nuanced statement that relates to a *likely* range of warming contributed to by human drivers.

3.2 Overstating findings in underlying sources

Although we did not do a detailed audit of NCA5’s use of source material, spot checks turned up evidence of a pattern of overstatement.

Chapter 2 page 11 reports on an increase in precipitation in some areas and attributes it to “climate change”:

Many eastern regions of the country are getting wetter (Figure 2.4). Average annual precipitation from 2002-2021 was 5%-15% higher relative to the 1901-1960 average in the central and eastern US, a trend attributable to climate change.

The change metric in NCA5 Figure 2.4 is non-standard; we will discuss NCA5’s inconsistent choices of time scales of analysis below. The claims were attributed to Knutson and Zeng (2018). But Knutson and Zeng did not say these things. They examined linear trends over 1901 – 2010, 1951 – 2010 and 1981 – 2010. They did not compare average rainfall over 2002 - 2021 to average rainfall over 1901 – 1960, if only because their study was published in 2018. For 1981-2010, they noted stronger trends in some areas but cautioned that such changes are consistent with natural variability, and they did not claim attributable trends were observed over the United States:

Observed annual precipitation trends over the recent 30-yr period 1981–2010 (Fig. 5) have generally stronger magnitudes (in mm yr⁻¹ decade⁻¹) than observed trends for 1901–2010 or 1951–2010. This is as expected since trends over a shorter period have stronger potential for occurrence of pronounced temporary trends due to internal variability alone. Only 9% of the analyzed area has detectable and attributable anthropogenic influence (categories –3, –2,

+2, +3), which represents less than one-third of the fractional areal coverage of such trends for 1901–2010 (29%). ... Eight percent of the analyzed area has attributable anthropogenic *increases* (categories +2, +3), including parts of eastern Europe, northern Asia, northern Australia/Maritime Continent, and tropical Africa.

As another example of overstating findings, NCA5's Chapter 2 page 18 states

There is robust evidence that human-caused warming has contributed to increases in the frequency and severity of the heaviest precipitation events across nearly 70% of the US.

This is allegedly attributed to two papers Diffenbaugh *et al.* (2018) and Kirchmeier-young and Zhang (2020). Diffenbaugh *et al.* presented ratios of observed occurrences of extreme events to simulated occurrence rates in CMIP6 models run with only natural forcings. They report that for 79% of the U.S. extreme rainfall event frequencies are currently higher than in model simulations, and the ratio of occurrences will rise under future warming simulations. This is not “robust” evidence of anthropogenic influence since it requires readers to assume that climate models provide accurate simulations of regional precipitation patterns, something that even IPCC AR6 admits is uncertain (AR6 WGI SPM Box SPM 1.2, SPM Section C.1.3).

Kirchmeier-Young and Zhang looked at extreme 1- and 5-day events in North America and, using three GCMs, found

A signal of combined anthropogenic and natural external forcing can be detected in the intensification of extreme precipitation at the continental scale over North America. In some cases, this intensification can be attributed to human influence specifically.

However, they noted large differences among the three models in their simulated precipitation changes. Also, two of the three models failed to yield attribution for 5-day events for the North America mean. In other words the models disagreed on whether the observed changes were anthropogenic. Both cited references utilized the implausible RCP8.5 scenario and began their “historical” observational records only in 1961. Here again this is not “robust” evidence, it is merely suggestive, particularly since other studies have found natural variability predominant.

3.3 Technical example: Emergent constraints

Some of the overconfidence expressed by NCA5 arises by omitting discussion of counterevidence in the peer reviewed literature. An example is the topic of “emergent constraints”. Chapter 3 page 17 invokes this concept to support its claim that key uncertainties have been reduced:

An approach to reduce uncertainty in climate change projections has matured over the past decade. It is known as “emergent constraints.” The term refers to strong statistical relationships between highly uncertain future climate parameters and observable trends or variations in the current climate, along with a physical explanation of this relationship.

Emergent constraints appeared in the climate modeling literature as an attempt to tie GCM behavior to climate observations in hopes of generating insight into real-world equilibrium climate sensitivity to a doubling of carbon dioxide (ECS). Climate models exhibit a wide range of ECS values. The idea of emergent constraints is to examine whether the models with shared sensitivity values also share a common representation of some climate process (usually related to clouds) that might indirectly

influence ECS. Suppose, for instance, that in low-ECS models the total cloud fraction in the tropics is strongly correlated with that in the southern midlatitudes but in high-ECS models the correlation is weak. Then researchers could examine whether the observed correlation is strong or weak and draw a conclusion about which type of model, and therefore which ECS value, is more likely.

A problem in the emergent constraint literature is that there has been a proliferation of proposed correlations with little physical motivation. As shown by Schlund *et al.* (2020) many emergent constraints patterned on CMIP5 models (Coupled Model Intercomparison Project No. 5, used for the IPCC 5th Assessment Report) failed to work on CMIP6 models (used for the IPCC 6th Assessment Report). In other words, the observed correlations in CMIP5 models between ECS and cloud processes failed to show up in CMIP6 models, indicating that they were likely spurious rather than clues to physical processes governing the climate system. As a result, emergent constraints estimated on CMIP5 models increased the uncertainty of ECS, rather than narrowing it as intended and as claimed by NCA5.

Schlund *et al.* summarized the problem as follows [**boldface** used for emphasis]

In this study, we systematically analyze 11 published emergent constraints on ECS that have mostly been derived from models participating in the Coupled Model Intercomparison Project Phase 5 (CMIP5) project... The focus of the study is on testing if these emergent constraints hold for [Earth System Models] participating in the new Phase 6 (CMIP6). Since none of the emergent constraints considered here have been derived using the CMIP6 ensemble, CMIP6 can be used for cross-checking of the emergent constraints on a new model ensemble. **The application of the emergent constraints to CMIP6 data shows a decrease in skill and statistical significance of the emergent relationship for nearly all constraints, with this decrease being large in many cases.** Consequently, the size of the constrained ECS ranges (66% confidence intervals) widens by 51% on average in CMIP6 compared to CMIP5.

Yet NCA5 described the use of emergent constraint analysis as a great “advance” that reduced uncertainty.

4 RELIANCE ON SHORT TIME PERIODS FOR TREND ANALYSIS

In CWG25 Chapter 6 we discussed the need for care in the choice of time scale when making claims about trends in extreme weather. We provided examples from analysis of river flooding, heatwaves, and extreme precipitation to show how assertions about apparent trends based on short data sets fall apart when looking at longer versions of the same data sets. Here are some examples of this problem from NCA5.

4.1 Average and Extreme Precipitation

McKittrick and Christy (2019) showed that apparently significant positive trends in U.S. average and extreme precipitation over the NCA4 interval (1901 – 2016) disappeared on longer samples (extending back as far as the 1840s, depending on location) or on a shorter interval coinciding with the final 40 years of the data then available (1978 – 2017). In CWG25 Section 6.4 we presented analyses of updated data for the same locations (and many others), in all cases finding both

considerable regional heterogeneity and that trends detectable on one time scale are often not detected on longer or shorter time scales. These findings argue against simple attribution of changes to anthropogenic influences.

NCA5 did not continue the NCA4 precedent of using the post-1901 interval as the time scale for its precipitation discussion; instead it refers to changes “since the 1950s”; NCA5 Figure 2.8 suggests 1958 might be the intended start date. Under Key Message 2.2 “Extreme Events Are Becoming More Frequent and Severe” (p. 2-16) NCA5 states (p. 2-18):

Rainfall is becoming more extreme

Since the 1950s, there has been an upward trend in heavy precipitation across the contiguous US. This increase is driven largely by more frequent precipitation extremes, with relatively smaller changes in their intensity.

In addition to our concerns that inferences about trends are contingent on choice of time scale, we cannot reproduce the finding that positive trends are observed in extreme precipitation across all CONUS regions. We extended the data used in CWG25 (McKittrick and Christy 2025) to include 141 stations across the US in the Pacific Coast, Midwest, Northeast and Southeast regions (Christy 2025). See details in Appendix 3. Many post-1950 trends are positive but statistically insignificant depending on the measure of extreme precipitation. It is possible to find locations that support the NCA5 position, such as the Southeast post-1950, but results are not robust to selecting longer or shorter time scales of analysis nor do they generalize across all regions.

The following is a more accurate summary of what U.S. data show.

There are regionally heterogeneous changes in average and extreme precipitation. Positive trends in annual average rainfall and extreme events (defined either as the annual maximum or the number of exceedances of the 99th percentile value) are generally weak or non-existent when looking at samples exceeding 130 years in length. Significant trends can be found when beginning the sample in the 1950s although in most cases the trends weaken and become insignificant when looking at the post-1980 interval. This makes attribution of changes in precipitation to anthropogenic warming difficult.

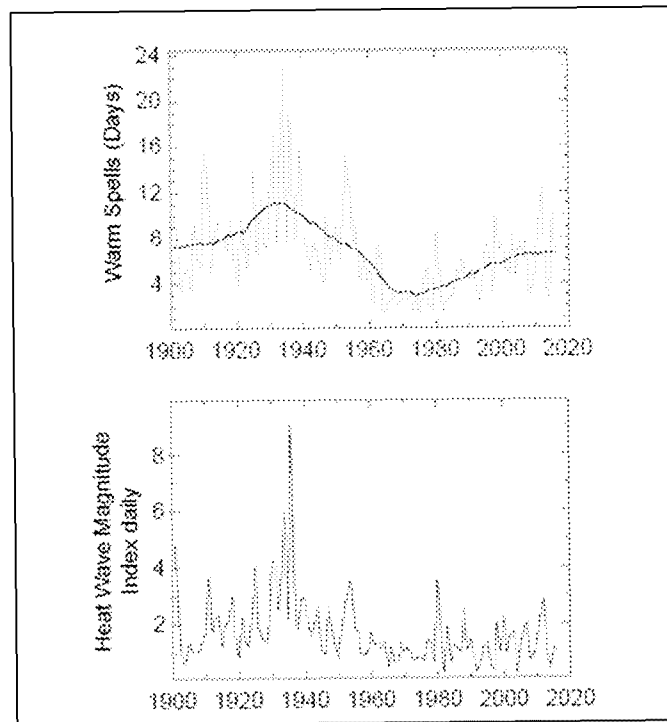
4.2 Heatwaves

In contrast to NCA5, NCA4 examined heat extremes across the entire 20th century, pointing out that peak heat wave activity was reached in the 1930s and has decreased since then, and that recent increases are confined to areas west of the Rockies:

[The] warmest daily temperature of the year increased in some parts of the West over the past century, but there were decreases in almost all locations east of the Rocky Mountains. In fact, all eastern regions experienced a net decrease, most notably the Midwest (about 2.2°F [1.2°C]) and the Southeast (roughly 1.5°F [0.8°C]).

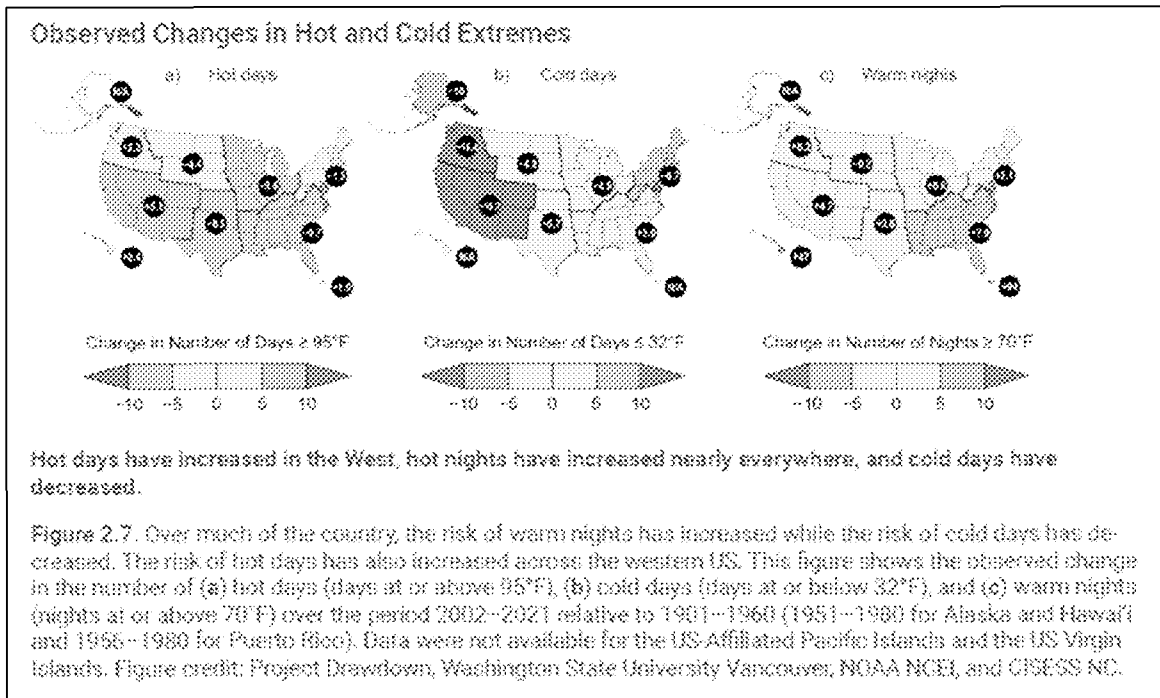
Since the mid-1960s, there has been only a very slight increase in the warmest daily temperature of the year (amidst large interannual variability). Heat waves (6-day periods with a maximum temperature above the 90th percentile for 1961–1990) increased in frequency until the mid-1930s, became considerably less common through the mid-

1960s, and increased in frequency again thereafter. As with warm daily temperatures, heat wave magnitude reached a maximum in the 1930s. (NCA4 pp. 190-191)



U.S. Heat waves since 1900. Source: NCA4 Figure 6.4

Contrast this careful and factual language with NCA5 Key Message 2.2: “Extreme Events Are Becoming More Frequent and Severe.” This blanket statement is followed by NCA5 Figure 2.7 (reproduced below) which shows the number of hot days, cold days and warm nights (respectively in panels a—c) over the period 2002-2021 compared to 1901-1960. [Presumably these are annual counts, although not stated in the caption.]



Close inspection shows that this figure contradicts the NCA5 Key Message with respect to heatwaves and instead reinforces the position of NCA4. Notwithstanding Key Message 2.2 the leftmost panel in Figure 2.7 above shows that over most of CONUS the number of extreme heat days has decreased in recent decades compared to the prior century.

The accompanying discussion in NCA5 becomes convoluted as it appears to be aimed at supporting the Key Message despite the contrary evidence. NCA5 chapter 2 elaborates on Key Message 2.2 by saying (page 16):

Observations show an increase in the severity, extent, and/or frequency of multiple types of extreme events. Heatwaves have become more common and severe in the West since the 1980s (*high confidence*).

But while it mentions the increase in hot days in the West NCA5 fails to mention the decrease everywhere east of the Rockies. On the next page (page 17) it raises the comparison to the 1930s then switches to discussing global counts:

By some measures, the most extreme heatwaves on record in the United States occurred during the Dust Bowl era of the 1930s. ... Globally such heatwaves are becoming more frequent, and in recent decades the western United States has been following those trends.

The reference to a global trend seems to be an attempt to tie heatwaves to anthropogenic climate change. But the obvious question, unaddressed by NCA5, is why one region follows the global pattern of increasing heatwaves while most of the country is trending in the opposite direction. These issues are addressed in Chapter 6 of CWG25, demonstrating that the range and magnitude of extreme temperatures (10s of degrees) are driven more by natural variability than by the small anthropogenic forcing. The analysis in CWG25 shows that for both (a) hot days ($\geq 95^{\circ}\text{F}$) and (b) number of days in heatwaves, the current decade is no hotter than a century ago in the U.S. Thus, the NCA5 claim that

“multiday heatwaves have become hotter, more frequent, larger, and longer lasting in recent decades,” is simply false when expanding the temporal and spatial domains to encompass all available data (Chapter 6 and Figure 6.3.6 of CWG25).

NCA5 then pointed to the dramatic Pacific Northwest heatwave of 2021. CWG2025 Section 8.6.1 discussed this event in detail, reviewing the multiple peer reviewed studies that explained the unusual meteorological context was unrelated to human-caused climate change, a point omitted from the NCA5 discussion.

NCA5 finally addresses the declining heatwave trend in CONUS east of the Rockies but attempts to reframe it by focusing on urban warm spells.

[The] number of very hot days has actually decreased across the central and eastern regions due to summer cooling trends in the region (Figure 2.7; Ch. 22). This does not, however, mean the central and eastern US are not affected by heat. The impacts of extreme high temperatures are more severe if such conditions persist for several days, and overall, multiday heatwaves have become hotter, more frequent, larger, and longer lasting in recent decades. Across 50 large US cities, the US Global Change Research Program heatwave indicator (<https://www.globalchange.gov/indicators/heat-waves>) shows that the average number of heatwaves has doubled since the 1980s, and the length of the heatwave season has increased from about 40 days to about 70 days.

We discussed part of NCA5 in CWG25 Section 6.3. The figure referenced by NCA5 uses an *ad hoc* definition of heat wave, namely two consecutive days with minimum nighttime temperatures above the 85th percentile, and an *ad hoc* time scale which begins in the 1960s, the coldest decade in the last century, thus suppressing any comparison to the 1930s. Further, nighttime temperatures in urban areas have increased faster than daytime temperatures (which NCA5 acknowledges), but this is a signature of urban heat islands and not a good metric of climate change. CWG25 noted as well that the occurrence of hot days ($\geq 95^{\circ}\text{F}$) has recently increased in the West, but declined in the remainder of the country, and in the nationwide average, since 1899.

5 INADEQUATE TRACEABLE ACCOUNTS

NCA3 began the practice of including a section on Traceable Accounts at the end of each chapter. This is the description from NCA5:

Each chapter concludes with a section entitled Traceable Accounts, which provides information on the overall process used to develop the chapter as well as a separate Traceable Account section for each Key Message. These Traceable Accounts describe the supporting evidence behind each Key Message, the process and rationale authors used in reaching their conclusions, and the author team’s expert assessment of the confidence in and, where applicable, likelihood of these conclusions. As such, Traceable Accounts provide information about the state of the science, document sources of uncertainty, identify research gaps, and allow traceability to data and resources.

The Traceable Accounts for each Key Message includes the following sections:

- Description of Evidence Base
- Major Uncertainties and Research Gaps
- Description of Confidence and Likelihood

The Traceable Accounts could have addressed the statutory requirement that the NCA discuss scientific uncertainties. They could also help satisfy the Executive Order for Restoring Gold Standard Science by addressing reproducibility, transparency, communication of error and uncertainty, and skepticism of findings and assumptions. However, the Traceable Accounts in NCA5's Chapters 2 and 3 are uneven, often superficial and uninformative.

An example of a deficient Traceable Account is NCA5's Key Message 2.2: "Extreme Events are Becoming More Frequent and Severe". The "Description of the Evidence Base" offers two paragraphs, the first summarizing the findings and the second generically describing the types of data that can be used for storms. "Major Uncertainties and Research Gaps" focuses on the uneven distribution across U.S. populations due to differences in exposure and vulnerability. The only limitations in data referred to are the lack of a long-term record of lightning and the lack of homogenized daily and hourly temperature data apart from reanalysis products.

But the most astonishing deficiency is in the "Description of Confidence and Likelihood." One of the statements in Key Message 2.2 is:

Hurricanes have been intensifying more rapidly since the 1980s (high confidence) and causing heavier rainfall and higher storm surges (high confidence).

The Description of Confidence and Likelihood includes the following statement:

Basic physical understanding and climate models both provide robust explanations for the links between climate change and observed changes in these extremes: this is why the authors also have high confidence that storms are delivering more rainfall and high confidence that storm surges are becoming higher.

No reference to journal publications or a specific data set is made anywhere in the Chapter regarding hurricane-induced precipitation or storm surge to support this *high confidence* conclusion.

The Traceable Accounts for the various Key Findings of Chapter 3 have some substantial inconsistencies. Consider

Key Message 3-1: Human activities have caused global warming.
Confidence and Likelihood: "There is *very high confidence* that emissions of GHGs from human activities, fossil fuel use in particular, have *unequivocally* caused all global warming observed over the industrial era. There is also *very high confidence* that changes in natural climate drivers have had globally small and regionally variable long-term effects over this period."

The Uncertainties section addresses only uncertainties in radiative forcing by greenhouse gases. In contrast, the Traceability Analysis of Key Message 3-4 ("Humans Are Changing Earth System Processes") raises the problem that relatively little is known about the role of natural variability at the regional scale. From its Description of Evidence Base:

In the last decade, there has been increasing recognition of the role of regional-scale natural variability in the past and future evolution of climate, as well as the fact that regional natural variability signals can be competitive with forced anthropogenic signals.

And from its Major Uncertainties and Research Gaps:

For example, the true natural variability of the climate system on decadal to centennial timescales could be larger than what we estimate from GCMs, which would further increase the irreducible uncertainty stemming from natural variability.

These statements are among the most scientifically credible in the entire NCA5 and they directly undercut the confidence assigned to Key Message 3-1.

There is also a generic problem in tracing NCA5's Traceable Accounts. The Front Matter of NCA5 states:

Each figure and some tables are accompanied by a metadata survey, which can be accessed in the online version of the report by clicking on the eyeball icon above the figure or table (see the table below for explanations of additional icons used throughout the report). The metadata survey describes data sources, figure or table development methods, copyright information, and other important documentation.

Clicking on the eyeball icon does not reveal the metadata information, instead a "Contact Us" email appears, addressed to the USGCRP. This is clearly an inadequate way to archive the metadata information.

In summary, the Traceable Analyses examined here, with few exceptions, fail to meet the stated objectives set forward by the NCA.

6 OVEREMPHASIS ON EXTREME SCENARIOS

To respond to the GCRA mandate to "project major trends for the subsequent 25 to 100 years," NCA5 relies on projections of future climate change based on estimates of future emissions (the so-called SSP scenarios) and/or specified levels of radiative forcing (the RCP scenarios). For the most part, NCA5 uses scenarios developed for the IPCC Assessment Reports.

In CWG Section 3.2.1 we presented a critical assessment of past and current IPCC scenario envelopes, showing that they have tended to overshoot observed emissions. The IPCC AR6 published in 2021 stated that "The likelihood of high-emission scenarios like RCP8.5 and SSP5-8.5 is considered low in light of recent energy sector developments." and that same year UN Climate Negotiators (COP) stopped using scenarios above 4.5.

NCA5 makes the following observations about the scenarios they use:

NCA5 authors were advised to assess the full range of scenarios available. (Front Matter)

Scenarios of future emissions and land-use change are developed as plausible alternatives, but no relative likelihood is attached to them. Some recent studies, however, have argued that the highest scenario, SSP5-8.5, is no longer plausible without a reversal of current trends in the adoption of renewables and energy efficiency. (Key Message 3.3 Traceable Analysis)

Despite acknowledging the issue, NCA5 otherwise ignored the problem. A keyword search of NCA5 of mentions of RCP/SSP scenarios finds over 50% referred to the extreme emissions scenarios RCP8.5/SSP5-8.5. Further, nine NCA5 figures (5.2, 6.9, 7.4, 11.3, 14.6, 22.13, 22.19, 27.9, 29.13) included *only* the 8.5 scenarios.

The problem of relying on extreme scenarios is particularly acute for NCA5's sea level rise projections. The sea level rise scenarios used in NCA5 do not relate directly to the SSP emissions scenarios, but rather to specified amounts of sea level rise by 2100. Table 4 of NCA5's "Guide to Using this Report" reproduced below shows that Low relates to 0.3 m (0.98 feet), Intermediate-Low relates to 0.5 m (1.64 feet), Intermediate relates to 1.0 m (3.28 feet), Intermediate-High relates to 1.5 m (4.92 feet), and High relates to 2.0 m (6.56 feet).

Table 4. Descriptive Terms for Common Sea Level Rise Scenarios Used in NCA5						
Future global mean sea level rise and sea level rise along United States coastline are shown for five scenarios in feet (and meters), relative to a 2000 baseline. The US values shown in the right half of the table are averaged across the US coastal regions, including the contiguous US, Alaska, Hawaii and the US-Affiliated Pacific Islands, and the US Caribbean. The national values shown in the table differ substantially from regional values. For example, sea level rise is higher in the Gulf Coast and lower or even negative in some parts of Alaska. In the next 30 years (2020–2050), sea level along the contiguous US coasts is expected to rise 0.92 feet (0.28 m), the same amount of sea level rise observed over the last 100 years (1920–2020). See Chapter 9 for regional sea level information. Adapted from Sweet et al. 2022.*						
Sea Level Rise Scenario Descriptor	Global Mean Sea Level			United States		
Year	2050	2100	2150	2050	2100	2150
Low	0.49 (0.15)	0.98 (0.3)	1.31 (0.4)	0.59 (0.18)	0.98 (0.3)	1.64 (0.5)
Intermediate-Low	0.66 (0.20)	1.64 (0.5)	2.62 (0.8)	0.75 (0.23)	1.64 (0.5)	2.95 (0.9)
Intermediate	0.92 (0.28)	3.28 (1.0)	6.23 (1.9)	0.89 (0.27)	3.28 (1.0)	6.89 (2.1)
Intermediate-High	1.21 (0.37)	4.92 (1.5)	8.86 (2.7)	1.12 (0.34)	4.92 (1.5)	8.86 (2.7)
High	1.41 (0.43)	6.56 (2.0)	12.14 (3.7)	1.38 (0.42)	6.56 (2.0)	12.46 (3.8)

Table 4 from the Front Matter of NCA5

Considering only projections representing processes quantified with at least medium confidence, IPCC AR6 assessed global mean sea level projections for 2100 to fall between 0.2 and 1.6 m (5th—95th percentile range). Nevertheless, the range of sea level rise scenarios considered by NCA5 extends to 2.0 m. Further, NCA5 fails to include plausible lower scenarios, such as 0.2 m cited by the IPCC, which also corresponds to the average rate of sea level rise over the past century.

Chapter 9 of NCA5 offers the following predictions of sea level rise:

“Under a range of potential global warming levels, average sea level along US coastlines is *likely* to be between 12 and 20 inches above 2000 sea levels in 2050 (Figure 9.2).”

These values span from the Intermediate scenario to values slightly greater than the High scenario. They can be put into context by considering the observed global sea level rise from 2000-2024, approximately 3.39 inches (0.28 feet). NCA5 is thus projecting a sea level rise during 2025 and 2050 that is 3.5 to 5.8 times the rate observed during 2000-2024, an exceedingly implausible outcome. Chapter 9 further states:

“Looking toward the future, an 11 inch (28 cm) average rise along the contiguous US coastline is expected by 2050 (relative to 2020), with a *likely* range of 9-13 inches.”

...

“There is *high confidence* and it is *likely* that sea levels will rise about 11 inches (likely range of about 9–13 inches) between 2020 and 2050”

In summary, NCA5 presents future sea level rise scenarios that are not directly relatable to either SSP/RCP emissions scenarios nor to global warming levels. The NCA5 scenarios include two scenarios that are higher than the 95th percentile for the extreme emissions scenario RCP8.5 and include hypothesized ice sheet processes in which there is low confidence. Projections to 2050 require rates of sea level rise from 2025 to 2050 that are more than triple the rate observed during 2000-2024. Further, NCA5 ascribes *high confidence* to these sea level rise projections. CWG25 Section 7.3 provides further context for USGCRP projections of extraordinary sea level rise in the next 25 years.

More generally, NCA5’s inclusion, and even focus, on implausible extreme emissions scenarios supports projections of alarming impacts that are very unlikely to be driven by anthropogenic warming.

7 CONFLATION OF NATURAL AND ANTHROPOGENIC CLIMATE CHANGES

[I’ve made a start here – others need to weigh in]

NCA5’s Glossary defines “climate change” as a change in climate for any reason. This is technically correct, but at variance with the (now) popular perception of all climate changes being anthropogenic. The distinction is not academic- it is central both to attribution questions and to projections, since anthropogenic changes would respond to mitigation, while natural changes are unavoidable.

NCA5’s use of the term “climate change” is ambiguous

As a result, NCA5’s attribution of various climate trends to “climate change” is misleadingly ambiguous. Consider its statement on precipitation that we cited in Section 3.2:

Many eastern regions of the country are getting wetter (Figure 2.4). Average annual precipitation from 2002-2021 was 5%-15% higher relative to the 1901-1960 average in the central and eastern US, a trend attributable to climate change.

The attribution is superfluous because the statement is a tautology by NCA5's definition of climate change. But its gratuitous inclusion effectively attributes the observed trend to greenhouse gas emissions.

Exploitation of the ambiguity in "climate change" is endemic to NCA5. The NASEM review (pp. 23-24) commented on this problem, and it could have been easily addressed by adopting the phrase "changing climate" for general changes while reserving the term "climate change" for anthropogenic changes. But the NCA5 authors seemingly ignored their recommendation.

Here are some other examples where NCA5 had problems with natural variability ...

NASEM praised Chapter 2, saying:

The chapter [2] meets the requirements of Section 106 of the GCRA.

Yet contrary to the requirements of Section 106, Chapter 2 did not adequately discuss natural variability let alone assess the full climate record available for quantifying natural variability. Chapter 2 actually minimizes natural variability by claiming (unsubstantiated) skill in attributing recent extremes to human causes. For example NCA5's Chapter 2 Introduction states,

"...recent advances in attribution science (KM 3.3) mean that the role of climate change in some extreme events can now be quantified in real time. For example, climate change made the record-breaking Pacific Northwest heatwave of June 2021 2° to 4°F hotter, and in 2017 ..."

CWG25 reviews the expert literature demonstrating that this particular event would have happened with or without climate change and that for CONUS, hot extremes are no more frequent now than they were in the past. NASEM did not challenge the unsubstantiated attribution claims in NCA5.

Notwithstanding NASEM's claim that the Chapter complies with Section 106 of the GCRA, it then acknowledged the absence of discussion of natural variability:

...the discussion and references regarding the role of natural climate variability and its regional differences are missing.

While a nod to natural variability is occasionally found in NCA5, it is usually followed by a "however" to emphasize human influence. One example is the statement just before the claim mentioned above pertaining to extreme event attribution: "There has always been extreme weather, which occurs even in an unchanged climate due to the natural variability of the Earth system. However, recent advances in attribution science (KM 3.3) mean that the role of climate change in some extreme events can now be quantified in real time..."

We pointed out (Section 4.2) that the evidence regarding heatwaves directly contradicts Key Message 2.2. NASEM did not mention this, instead it focused on a somewhat esoteric issue of terminology:

"Extreme Events Are Becoming More Frequent and Severe."

Key Message 2.2 is another generally well written key message. However, while the title

of this key message includes the word “risk,” the key message is exclusively about hazard. The Committee suggests rewriting the key message title to more accurately reflect the discussion on hazards.

The NASEM review appears to accept NCA5’s use of short data records because it makes no critical remarks about the failure to assess long time series, except for its observation that the use of short records makes the omission of natural variability that much more of a problem:

It is also important to point out that the influence of natural climate variability becomes particularly strong when the climate trend is computed based on short periods of time or small geographic areas.

This comment was largely ignored in the NCA5 final text.

8 SUMMARY EVALUATION OF NCA5 AND RECOMMENDATIONS FOR NCA6

This chapter summarizes our evaluation of NCA5 relative to OSTP’s charge: whether NCA5 (1) complied with the USGCRP’s statutory obligation; (2) adheres to the core tenets of Gold Standard Science; and (3) can suitably inform federal climate and energy policy. The points made in this summary analysis refer to specific sections of this report as well as to the CWG25 report.

8.1 Compliance with USGCRP’s statutory obligation

As cited in Section 1.2 of this report, the Global Change Research Act requires an assessment that:

- (1) integrates, evaluates, and interprets the findings of the [Global Change Research] Program and discusses the scientific uncertainties associated with such findings;
- (2) analyzes the effects of global change on the natural environment, agriculture, energy production and use, land and water resources, transportation, human health and welfare, human social systems, and biological diversity; and
- (3) analyzes current trends in global change, both human-induced and natural, and projects major trends for the subsequent 25 to 100 years.

We deem NCA5 to have fallen short when evaluated against these criteria because of the following major shortcomings in NCA5 (each is detailed in the chapters cited):

- Inadequate assessment of the relevant topics in climate science and the hazard < [RM: I’m not sure what *hazard* is referring to. We haven’t defined the term or discussed it] [I think it’s OK as is, as risk = hazard X vulnerability] components of climate impacts. NCA5 instead focuses on evaluation of societal vulnerabilities, “Climate Action,” and policy recommendations with a social justice emphasis (Section 1.2).
- Overconfidence in conclusions and inadequate assessment of uncertainties (Section 3.1.5)
- Inadequate discrimination between natural and human-induced causes of trends and impacts (Chapter 7)

- Inadequate analysis of climate trends by relying on short time periods (Chapter 6)
- Uncritical evaluation of emission scenarios and climate simulations in making projections for the next 25 to 100 years (Chapter 6; Section 3.2.1 and Chapter 5 of CWG25).

8.2 Adherence to the tenets of Gold Standard Science

With respect to the tenets of Gold Standard science listed in Section 1.2 of this report, we have identified the following major shortcomings in NCA5:

- **Lack of reproducibility.** In the few examples that we examined closely, we identified an instance where we could not reproduce the findings of the NCA5, a task that should require only rudimentary data analysis (Section 4.1)
- **Lack of transparency.** In many instances, the Traceable Account fails to justify the Key Finding. Metadata was not readily accessible. (Chapter 5)
- **Inadequate communication of error and uncertainty.** The Traceable Account for each Key Message provides a section on Major Uncertainties and Research Gaps; most of the accounts that we examined were superficial and uninformative. (Chapter 5)
- **Not skeptical of findings and assumptions.** The main text of the chapters is, with few exceptions, not skeptical of its findings and assumptions. (Chapters 3, 5)
- **Some hypotheses and Key Messages are not falsifiable.** Key Message 13.4 is but one of many examples: “Equitable Distribution of Transportation Trade-offs and Benefits Requires Community Involvement.”
- Failure to acknowledge benefits of warming and additional atmospheric CO₂ (CWG25 Section 2.1, Chapter 9)
- **Inadequacy of the peer review process.** The review of the NCA5 Third Order Draft by National Academies of Science, Engineering and Medicine (NASEM) identified some of the deficiencies we have noted, but the NCA5 authors were not obligated to adopt the NASEM recommendations. More importantly, we’ve identified many other deficiencies in NCA5; the NASEM review **did not point them out and thus** evidently lacked the rigor expected of Academies’ reports. (Section 1.4, Chapter 7)

8.3 Suitability for informing Federal climate and energy policy

We assess that the selection and presentation of information in NCA5 makes it an unreliable basis for U.S. climate and energy policymaking. For each of the elements of knowledge characterization suitable for risk management listed in Section 1.3, here are specific examples where NCA5 falls short:

- The degree to which the assumptions made are reasonable/realistic based on background knowledge
 - NCA5 focused on implausibly extreme scenarios for emissions and sea level rise scenarios **and made policy recommendations without adequate consideration of the costs**
- The degree to which data/information exists and are reliable and relevant
 - NCA5’s **assumptions about model reliability, and its use of** short time periods for analysis does not support its high-confidence conclusions
- The degree to which there is disagreement among experts, including those from different environments or academic fields

- While NCA5 was an interdisciplinary effort, the concerns we have raised all point to a failure to canvass or communicate the full range of evidence including data and research findings that speak against Key Messages.
- The degree to which the phenomena involved are understood and accurate models exist
 - NCA5 is not appropriately skeptical of the ability of climate models to attribute the causes of warming and extreme events or to project future climates
- The degree to which the knowledge has been thoroughly examined with respect to unknown knowns
 - A major NCA5 shortcoming is its dismissal of natural climate variability in many contexts where it should have been a major consideration

NCA5 is also problematic for informing policy because its hyperbolic language promotes alarm and advocates for specific policies without proper analysis of marginal costs and benefits. In recent decades, climate science has engendered passion and emotion. Indeed, some younger climate scientists have gone into the field to “save the planet.” The NASEM Review of the NCA5 underscores the endemic nature of this problem – their review appears to be written by authors who share many of the biases of the NCA5 team, with an inordinate focus in the review on social and policy issues. It is then not surprising that objectivity can suffer when climate scientists communicate their understanding to non-experts. Further, the field of climate science has been politicized by NetZero mandates. This lack of objectivity usurps the public’s right to make informed choices and undermines their confidence in the scientific enterprise.

Philip Handler, President of the National Academy of Sciences, identified the problem forty-five years ago in an [editorial](#) that still resonates:

Difficulty arises in the scientific community from confusion of the role of scientist *qua* scientist with that of scientist as citizen, confusion of the ethical code of the scientist with the obligation of the citizen, blurring the distinction between intrinsically scientific and intrinsically political questions. When scientists fail to recognize these boundaries, their own ideological beliefs, usually unspoken, easily becloud seemingly scientific debate.

8.4 Recommendations for NCA6

While we have assessed NCA5 to be scientifically inadequate and unsuitable as a basis for decision-making, one can imagine a different National Climate Assessment that meets statutory and policymaker requirements. The goal should be not to persuade, but to impart understanding by being transparent and complete. A suitable NCA would be an important complement to IPCC work; to the extent that its conclusions differed from the oracular “consensus” of the IPCC reports and additional topics are addressed, it would promote a more open scientific discussion and a more informed policy debate.

We recommend that the NCA6 have a narrower scope than NCA5, refocusing on climate science, including natural climate variability, with topics to include:

- How the climate has changed, or not, in the distant and recent past
 - The U.S. has the best and longest meteorological records and they should be displayed in their entirety. Trend analyses should include longest periods available and employ suitable statistical methods. Local paleoclimate data should be considered where available. Analysis would demonstrate not only how the climate has changed, but

also the regional heterogeneity. Standard, easily understandable metrics should be employed.

- The range of climatic and weather conditions, including weather extremes, that can reasonably be expected to occur in U.S. regions over the near future for which planners and policymakers should be prepared.
- A critical survey of current global and regional modeling capabilities and their suitability for regional impact assessments and projections. This would include an assessment of their ability to reproduce observed changes. It would also discuss alternative methods where feasible for generating projections and forecasts on regional and decadal scales. Chapter 10 of the IPCC AR6 WGI provides a reasonable basis. NOTE I HAVE A LOT OF MATERIAL ON THIS
- Potential impacts of future changes on ecosystems and society. Assessment of the impacts of recent historical climate variability and change on ecosystems and society. Where long-term data indicate a detectable trend of a regional change, regional projections using climate models and storyline approaches can be used, targeted at the period 2030-2050. Emissions scenarios exceeding RCP4.5/SSP2-4.5 and models with ECS values > 4C should not be used

It would also be important to work at a level of detail appropriate to current science capabilities. The pressures toward spatially or temporally precise projections should be resisted as the current models are nowhere up to the task (an example is discussed in CWG25 Section 5.8). In that light, the many pages of NCA5 devoted to regional and sectoral impacts have little value. It would have been simpler and more accurate to say “we can’t predict at that level.” [Does this contradict the second bullet above?]

Given the substantial deficiencies in NCA5 that we have outlined, along with the endemic bias of the climate community towards alarmism and policy advocacy, producing NCA6 with the current NCA organizational construct would be a challenge. A NASEM review could help, but only if the selected participants reflect full viewpoint diversity and do not simply mirror the assumptions and biases of past NCA teams. We believe the CWG25 report to be a good start on NCA6 in terms of coverage, depth, and tone. It is certainly not the last word and will be subject to public comment and appropriate revisions.

More broadly, we recommend a refresh rewrite of the Global Change Research Act. The current mandate is vague and off point, allowing successive NCA teams to reinterpret the mandate as they see fit. Moreover, it is becoming increasingly clear that current and foreseeable models are not fit-for-purpose to describe regional climates, let alone usefully project them for 25 and 100 years. And the use of the term “global change” is ambiguous and outdated.

9 REFERENCES

- Aven, Terje (2017) “Improving Risk Characterisations in Practical Situations by Highlighting Knowledge Aspects, with Applications to Risk Matrices,” *Reliability Engineering & System Safety* 167 (November 2017): 42–48
<https://www.sciencedirect.com/science/article/pii/S0951832016306950>
- Climate Working Group (2025) Impacts of Carbon Dioxide Emissions on the U.S. Climate. Washington DC: Department of Energy, May 27, 2025.

- Dellawalla, Colette, Victor Ambrose, Carl Bergstrom *et al.* (2025) "Trump's new 'gold standard' rule will destroy American science as we know it." *The Guardian* May 29, 2025
<https://www.theguardian.com/commentisfree/2025/may/29/trump-american-science>
- Diffenbaugh, N.S., D. Singh, and J.S. Mankin, 2018: Unprecedented climate events: Historical changes, aspirational targets, and national commitments. *Science Advances*, 4 (2), 3354.
<https://doi.org/10.1126/sciadv.aao3354>
- Handler, Philip (1980) Public Doubts About Science. *Science* 208(4448) p. 1093
<https://www.science.org/doi/10.1126/science.208.4448.1093>
- Kirchmeier-Young, M.C. and X. Zhang, 2020: Human influence has intensified extreme precipitation in North America. *Proceedings of the National Academy of Sciences of the United States of America*, 117 (24), 13308-13313. <https://doi.org/10.1073/pnas.1921628117>
- Knutson, Thomas and Fanrong Zeng (2018) "Model Assessment of Observed Precipitation Trends over Land Regions: Detectable Human Influences and Possible Low Bias in Model Trends" *Journal of Climate* 31(12) <https://journals.ametsoc.org/view/journals/clim/31/12/jcli-d-17-0672.1.xml>
- Koonin, Steven (2024) *Unsettled: What Climate Science Tells Us, What It Doesn't, and Why It Matters*. ---: ---
- McKittrick, R., and J.R. Christy (2019). Assessing changes in US regional precipitation on multiple time scales. *Journal of Hydrology*, 578, 124074. <https://doi.org/10.1016/j.jhydrol.2019.124074>
- McKittrick, R., and J.R. Christy (2025), "Data and Code for DoE Report 2025", Mendeley Data, V1, doi: 10.17632/8n9ks93vn7.1
- National Academies of Sciences, Engineering, and Medicine. 2023. *Review of the Draft Fifth National Climate Assessment*. Washington, DC: The National Academies Press.
<https://doi.org/10.17226/26757>.
- NCA4. (2017). *Climate science special report: Fourth National Climate Assessment, Volume I* (D. J. Wuebbles, D. W. Fahey, and K. A. Hibbard, Eds.). U.S. Global Change Research Program.
<https://doi.org/10.7930/J0J964J6>
- NCA5. (2023). *Fifth National Climate Assessment* (A. R. Crimmins et al., Eds.). U.S. Global Change Research Program. <https://doi.org/10.7930/NCA5.2023.CH1>
- Pielke Jr., R. (2024). Scientific integrity and U.S. 'billion dollar disasters'. *npj Natural Hazards*, 1, Article 12. <https://www.nature.com/articles/s44304-024-00011-0>
- Pielke Jr., R. (2025, May 8). RIP NOAA's billion dollar disasters. The Honest Broker [Substack]. <https://rogerpielkejr.substack.com/p/rip-noaas-billion-dollar-disasters>
- Schlund, Manuel, Axel Lauer, Pierre Gentine, Steven C. Sherwood, and Veronika Eyring (2020) Emergent constraints on equilibrium climate sensitivity in CMIP5: do they hold for CMIP6? *Earth System Dynamics* 11 1233-1258 <https://doi.org/10.5194/esd-11-1233-2020>

APPENDICES

APPENDIX 1: Charge to the review

APPENDIX 2: Reproducibility of NCA5 claim of extreme precipitation trends

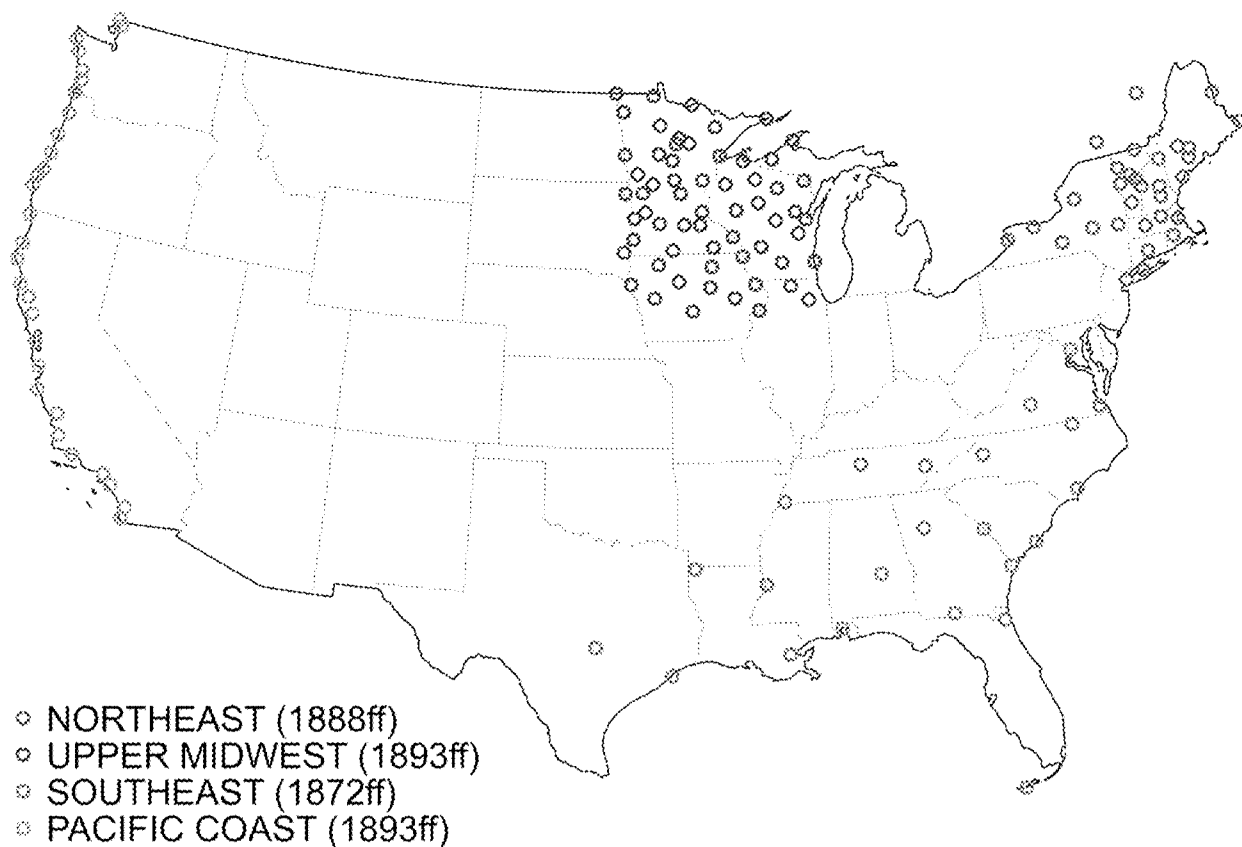


Figure A1: Stations used in the following analyses

Note: All data are available at Christy (2025). Methods as described in McKittrick and Christy (2019), code available at McKittrick and Christy (2025).

Table codes: (-) neg insignificant, -- neg significant, (+) pos insignificant, ++ pos significant.

Column 1: Measure

Column 2: Number of stations in that region

Column 3: Count of stations exhibiting a significant positive trend

Column 3: Count of stations exhibiting a significant negative trend

Column 5: Characteristic of region-wide trend

PACIFIC COAST

Since 1893:

	No. stns	+ trends	- trends	region
1-day average	29	0	1	(-)
2-day average	29	0	1	(-)
Avg on non-zero days	29	0	9	--
Variability	29	1	0	(+)
Annual max	29	2	1	(+)
Number of 99 th pct exceedances	29	1	0	(-)

Since 1950:

	No. stns	+ trends	- trends	region
1-day average	29	0	1	(-)
2-day average	29	0	1	(-)
Avg on non-zero days	29	0	4	(-)
Variability	29	2	3	(-)
Annual max	29	6	3	(-)
Number of 99 th pct exceedances	29	2	1	(-)

Since 1980:

	No. stns	+ trends	- trends	region
1-day average	29	0	0	(-)
2-day average	29	0	0	(-)
Avg on non-zero days	29	0	1	(-)
Variability	29	0	0	(-)
Annual max	29	2	1	(-)
Number of 99 th pct exceedances	29	0	0	(+)

SOUTHEAST

Since 1873:

	No. stns	+ trends	- trends	region
1-day average	24	1	1	(+)
2-day average	24	1	1	(+)
Avg on non-zero days	24	7	2	(+)
Variability	24	1	0	(+)
Annual max	24	2	0	(+)
Number of 99 th pct exceedances	24	5	0	(+)

Since 1950:

	No. stns	+ trends	- trends	region
1-day average	24	5	0	++
2-day average	24	5	0	++
Avg on non-zero days	24	5	1	++
Variability	24	6	0	++
Annual max	24	4	0	++
Number of 99 th pct exceedances	24	4	0	(+)

Since 1980:

	No. stns	+ trends	- trends	region
1-day average	24	5	0	(+)
2-day average	24	5	0	(+)
Avg on non-zero days	24	5	1	(+)
Variability	24	3	0	(+)
Annual max	24	4	0	(+)
Number of 99 th pct exceedances	24	4	0	(+)

MIDWEST

Since 1893:

	No. stns	+ trends	- trends	region
1-day average	61	23	0	++
2-day average	61	23	0	++
Avg on non-zero days	61	2	12	(+)
Variability	61	12	0	++
Annual max	61	9	0	(+)
Number of 99 th pct exceedances	61	10	0	(+)

Since 1950:

	No. stns	+ trends	- trends	region
1-day average	61	28	2	++
2-day average	61	28	2	++
Avg on non-zero days	61	11	1	++
Variability	61	16	0	(+)
Annual max	61	8	0	(+)
Number of 99 th pct exceedances	61	19	0	++

Since 1980:

	No. stns	+ trends	- trends	region
1-day average	61	6	1	(+)
2-day average	61	6	1	(+)
Avg on non-zero days	61	8	2	(+)
Variability	61	5	1	(+)
Annual max	61	0	1	(+)
Number of 99 th pct exceedances	61	5	3	(-)

NORTHEAST

Since 1888:

	No. stns	+ trends	- trends	region
1-day average	27	12	0	++
2-day average	27	12	0	++
Avg on non-zero days	27	7	1	(+)
Variability	27	4	0	(+)
Annual max	27	3	0	(-)
Number of 99 th pct exceedances	27	5	0	(+)

Since 1950:

	No. stns	+ trends	- trends	region
1-day average	27	12	0	++
2-day average	27	12	0	++
Avg on non-zero days	27	7	1	(+)
Variability	27	4	0	(+)
Annual max	27	3	0	(-)
Number of 99 th pct exceedances	27	5	0	++

Since 1980:

	No. stns	+ trends	- trends	region
1-day average	27	10	1	++
2-day average	27	10	1	++
Avg on non-zero days	27	6	0	(+)
Variability	27	2	0	(+)
Annual max	27	1	0	(+)
Number of 99 th pct exceedances	27	1	1	++

ABOUT THE AUTHORS

[Insert updated bios]

From: Steven Koonin [steven.koonin@gmail.com]
Sent: 6/23/2025 10:33:28 AM
To: 'John Christy' [climateman60@gmail.com]; 'Ross McKittrick' [ross.mckittrick@gmail.com]
CC: 'Judith Curry' [curry.judith@gmail.com]; 'Travis Fisher' [travis.scott.fisher@gmail.com]; 'Roy Spencer' [roywspencer@hotmail.com]; 'Josh Loucks' [loucksj14@gmail.com]; 'Seth Cohen' [seth.cohen@hq.doe.gov]
Subject: RE: Summary chapter

John- Does your point refer only to your comments or have you done a sampling of NASEM's and others comments?

SEK

From: John Christy <climateman60@gmail.com>
Sent: Sunday, June 22, 2025 8:34 PM
To: Ross McKittrick <ross.mckittrick@gmail.com>
Cc: Steve Koonin <steven.koonin@gmail.com>; Judith Curry <curry.judith@gmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>; Roy Spencer <roywspencer@hotmail.com>; Josh Loucks <loucksj14@gmail.com>; Seth Cohen <seth.cohen@hq.doe.gov>
Subject: Re: Summary chapter

Judy

Attached is the NASEM review.

Steve/Ross (not sure who is holding the Master)

After reading my public comments to the NCA5 3rd order draft, would it not be correct to say on page 3,

- The NCA5 authors failed to adopt some improvements recommended by NASEM and failed to address many credible public comments.

John C.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
climateman60@gmail.com

From: John Christy <climateman60@gmail.com>
Sent: Sunday, June 22, 2025 8:34 PM
To: Ross McKittrick
Cc: Steve Koonin; Judith Curry; Travis Fisher; Roy Spencer; Josh Loucks; Seth Cohen
Subject: Re: Summary chapter
Attachments: Untitled attachment.htm; NASEM Review of NCA5.pdf; Untitled attachment.htm

Judy

Attached is the NASEM review.

Steve/Ross (not sure who is holding the Master)

After reading my public comments to the NCA5 3rd order draft, would it not be correct to say on page 3,

- The NCA5 authors failed to adopt some improvements recommended by NASEM and failed to address many credible public comments.

John C.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
climateman60@gmail.com

[OBJ]

> On Jun 22, 2025, at 2:10 PM, Ross McKittrick <ross.mckittrick@gmail.com> wrote:

>

> Here are my edits to the conclusion chapter, highlighted in cyan to stand out. There were a few places where I thought we need to state the conclusions a bit more clearly. I've added a query about the term 'hazard'.

> I haven't looked at Ch 7 yet but will try to add to it tomorrow.

>

>

> On Sun, Jun 22, 2025 at 12:33 PM John Christy <climateman60@gmail.com <<mailto:climateman60@gmail.com>>> wrote:

>> Steve

>>

>> I'm trying to handle this from my phone, so a little rough. Your red-letter question about NCA's incorporation of alternative views is no problem. I have a few of the public comment submissions that were ignored, including separate submissions by Ross and myself. When I'm back in the office, I can find those. I'm wondering if we can find any information on NCA5's response to our submissions?

>>

>> It may be enlightening to add the phrase after your point about ignoring comments (I can't remember your exact words), "including public comment submissions by two CWG25 authors"

>>

>> John C.

>>

>> Sent from my iPhone

>>

>>> On Jun 22, 2025, at 6:42 AM, Steven Koonin <steven.koonin@gmail.com <<mailto:steven.koonin@gmail.com>>> wrote:

>>>

>>>

>>> I've now built on Judy's summary chapter 8, rationalizing it with Section 1.3. Note particularly the recommendations for NCA6.
>>>
>>>
>>> Also made a start on Chapter 7.
>>>
>>>
>>> Both are included in the integrated draft attached, which you are urged to read/comment/edit.
>>>
>>>
>>> SEK
>>>
>>>
>>> From: Judith Curry <curry.judith@gmail.com <<mailto:curry.judith@gmail.com>>>
>>> Sent: Saturday, June 21, 2025 10:32 AM
>>> To: Steven Koonin <steven.koonin@gmail.com <<mailto:steven.koonin@gmail.com>>>
>>> Cc: Travis Fisher <travis.scott.fisher@gmail.com <<mailto:travis.scott.fisher@gmail.com>>>; Roy Spencer
<roywspencer@hotmail.com <<mailto:roywspencer@hotmail.com>>>; Ross McKittrick <ross.mckittrick@gmail.com
<<mailto:ross.mckittrick@gmail.com>>>; John Christy <climateman60@gmail.com <<mailto:climateman60@gmail.com>>>; Josh Loucks
<loucksj14@gmail.com <<mailto:loucksj14@gmail.com>>>; Cohen, Seth <seth.cohen@hq.doe.gov <<mailto:seth.cohen@hq.doe.gov>>>
>>> Subject: Summary chapter
>>>
>>>
>>> Draft of summary chapter is attached, with short recommendations section (cleaned up from yesterday's version). I look forward
to your feedback
>>>
>>>
>>> Below is the recommendations section that I came up with, I'm sure this will be controversial but it will at least trigger the group
thinking about the issue:
>>>
>>>
>>> Recommendations
>>>
>>>
>>> In view of the substantial problems with NCA5 in failing to comply with the USGCRP mandate and the tenets of Gold Standard
Science, along with the endemic bias in the climate community towards alarmism and policy advocacy on the issue of climate change,
we do not see a clear path forward for the NCA6 at this time.
>>>
>>>
>>> The USGCRP mandate to the NCA should be revisited. The current mandate is vague and off point, and it is not entirely
surprising that successive NCA teams have interpreted the mandate differently. With regards to specific wording in the mandate, the
term "global change" is ambiguous and outdated; it is no longer used in most climate-related documents. It is becoming increasingly
clear that climate models are not fit-for-purpose for making regional projections 25 and 100 years in advance.
>>>
>>>
>>> There are three fundamental issues to be addressed in the near term to support the USGCRP and federal policy making:
>>>
>>> · Review of climate science (we suggest that the CWG25 Report meets this objective)
>>> · Comprehensive risk assessment of extreme weather and climate events
>>> · Evaluation of USGCRP portfolio of funded projects and recommendations for the future.
>>>
>>>

>>> SOMETHING ABOUT ENERGY POLICY???

>>>

>>>

>>>

>>>

>>>

>>>

>>>

>>>

>>>

>>>

>>> <~WRD2957.jpg>

>>>

>>> Judith Curry, President

>>> CFAN - Climate Forecast Applications Network

>>> Reno, NV USA

>>> curry.judith@cfanclimate.com <mailto:curry.judith@gmail.com> | +1.404.803.2012

>>> <http://www.cfanclimate.n> <<http://www.cfanclimate.com/>>et

>>>

>>>

>>>

>>>

>>> <01.NCA5.Review.June20[JC][SEK].docx>

> <01.NCA5.Review.June20[JC][SEK][JCurry][RM].docx>

Judy

Attached is the NASEM review.

Steve/Ross (not sure who is holding the Master)

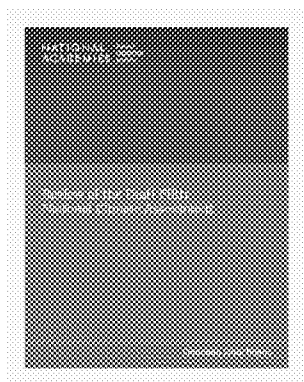
After reading my public comments to the NCA5 3rd order draft, would it not be correct to say on page 3,

- The NCA5 authors failed to adopt some improvements recommended by NASEM and failed to address many credible public comments.

John C.

John Christy
Director, Earth System Science Center
Professor, Atmos and Earth Science
Alabama State Climatologist
The University of Alabama in Huntsville
climatemanager60@gmail.com

This PDF is available at <http://nap.nationalacademies.org/26757>



Review of the Draft Fifth National Climate Assessment (2023)

DETAILS

344 pages | 8.5 x 11 | PAPERBACK

ISBN 978-0-309-69523-7 | DOI 10.17226/26757

CONTRIBUTORS

Committee to Review the Draft Fifth National Climate Assessment; Board on Atmospheric Sciences and Climate; Board on Environmental Change and Society; Division on Earth and Life Studies; Division of Behavioral and Social Sciences and Education; National Academies of Sciences, Engineering, and Medicine

BUY THIS BOOK

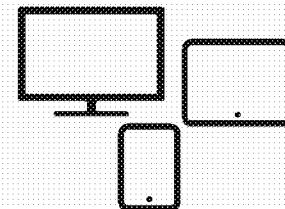
FIND RELATED TITLES

SUGGESTED CITATION

National Academies of Sciences, Engineering, and Medicine. 2023. *Review of the Draft Fifth National Climate Assessment*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/26757>.

Visit the National Academies Press at nap.edu and login or register to get:

- Access to free PDF downloads of thousands of publications
- 10% off the price of print publications
- Email or social media notifications of new titles related to your interests
- Special offers and discounts



All downloadable National Academies titles are free to be used for personal and/or non-commercial academic use. Users may also freely post links to our titles on this website; non-commercial academic users are encouraged to link to the version on this website rather than distribute a downloaded PDF to ensure that all users are accessing the latest authoritative version of the work. All other uses require written permission. (Request Permission)

This PDF is protected by copyright and owned by the National Academy of Sciences; unless otherwise indicated, the National Academy of Sciences retains copyright to all materials in this PDF with all rights reserved.

Review of the Draft Fifth National Climate Assessment

Committee to Review the Draft Fifth National Climate Assessment

Board on Atmospheric Sciences and Climate

Division on Earth and Life Studies

Board on Environmental Change and Society

Division of Behavioral and Social Sciences and Education

Consensus Study Report

NATIONAL ACADEMIES PRESS 500 Fifth Street, NW Washington, DC 20001

This activity was supported by a contract between the National Academy of Sciences and the National Aeronautics and Space Administration. Any opinions, findings, conclusions, or recommendations expressed in this publication do not necessarily reflect the views of any organization or agency that provided support for the project.

International Standard Book Number-13: 978-0-309-69523-7

International Standard Book Number-10: 0-309-69523-6

Digital Object Identifier: <https://doi.org/10.17226/26757>

This publication is available from the National Academies Press, 500 Fifth Street, NW, Keck 360, Washington, DC 20001; (800) 624-6242 or (202) 334-3313; <http://www.nap.edu>.

Copyright 2023 by the National Academy of Sciences. National Academies of Sciences, Engineering, and Medicine and National Academies Press and the graphical logos for each are all trademarks of the National Academy of Sciences. All rights reserved.

Printed in the United States of America.

Suggested citation: National Academies of Sciences, Engineering, and Medicine. 2023. *Review of the Draft Fifth National Climate Assessment*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/26757>.

The **National Academy of Sciences** was established in 1863 by an Act of Congress, signed by President Lincoln, as a private, nongovernmental institution to advise the nation on issues related to science and technology. Members are elected by their peers for outstanding contributions to research. Dr. Marcia McNutt is president.

The **National Academy of Engineering** was established in 1964 under the charter of the National Academy of Sciences to bring the practices of engineering to advising the nation. Members are elected by their peers for extraordinary contributions to engineering. Dr. John L. Anderson is president.

The **National Academy of Medicine** (formerly the Institute of Medicine) was established in 1970 under the charter of the National Academy of Sciences to advise the nation on medical and health issues. Members are elected by their peers for distinguished contributions to medicine and health. Dr. Victor J. Dzau is president.

The three Academies work together as the **National Academies of Sciences, Engineering, and Medicine** to provide independent, objective analysis and advice to the nation and conduct other activities to solve complex problems and inform public policy decisions. The National Academies also encourage education and research, recognize outstanding contributions to knowledge, and increase public understanding in matters of science, engineering, and medicine.

Learn more about the National Academies of Sciences, Engineering, and Medicine at **www.nationalacademies.org**.

Consensus Study Reports published by the National Academies of Sciences, Engineering, and Medicine document the evidence-based consensus on the study's statement of task by an authoring committee of experts. Reports typically include findings, conclusions, and recommendations based on information gathered by the committee and the committee's deliberations. Each report has been subjected to a rigorous and independent peer-review process and it represents the position of the National Academies on the statement of task.

Proceedings published by the National Academies of Sciences, Engineering, and Medicine chronicle the presentations and discussions at a workshop, symposium, or other event convened by the National Academies. The statements and opinions contained in proceedings are those of the participants and are not endorsed by other participants, the planning committee, or the National Academies.

Rapid Expert Consultations published by the National Academies of Sciences, Engineering, and Medicine are authored by subject-matter experts on narrowly focused topics that can be supported by a body of evidence. The discussions contained in rapid expert consultations are considered those of the authors and do not contain policy recommendations. Rapid expert consultations are reviewed by the institution before release.

For information about other products and activities of the National Academies, please visit www.nationalacademies.org/about/whatwedo.

COMMITTEE TO REVIEW THE DRAFT FIFTH NATIONAL CLIMATE ASSESSMENT

JOEL B. SMITH (*Chair*), Independent Researcher
MARISSA AHO, Washington State Department of Natural Resources
SHANONDORA BILLIOT, Arizona State University
MICHAEL DETTINGER (NAE), Scripps Institution of Oceanography and Desert
Research Institute
JANET FRANKLIN (NAS), San Diego State University
JADA GAROFALO, Abt Associates
SHINENG HU, Duke University
RICHARD JACKSON (NAM), University of California, Los Angeles
RACHAEL JONASSEN, The George Washington University
NATALIE MAHOWALD, Cornell University
REGAN F. PATTERSON, University of California, Los Angeles
YEUMING (LUCY) QIU, University of Maryland, College Park
CHARLES (CHUCK) RICE, Kansas State University
ANJALI SAUTHOFF, Independent Environmental Health Scientist
DAVID L. SKOLE, Michigan State University
PHILIP R. THOMPSON, University of Hawai‘i at Mānoa
KRISTIN TIMM, International Arctic Research Center, University of Alaska Fairbanks
GARY YOHE, Wesleyan University (*Emeritus*)

Study Staff

MORGAN DISBROW-MONZ, Study Director
RACHEL SILVERN, Program Officer
STEVEN STICHTER, Senior Program Officer
HANNAH STEWART, Associate Program Officer
LINDSAY MOLLER, Senior Program Assistant

BOARD ON ATMOSPHERIC SCIENCES AND CLIMATE

MARY GLACKIN (*Chair*), The Weather Company, an IBM Business (Retired)
CYNTHIA S. ATHERTON, Heising-Simons Foundation
ELIZABETH A. BARNES, Colorado State University
BRAD R. COLMAN, The Climate Corporation (Retired)
BART E. CROES, California Air Resources Board (Retired)
NEIL DONAHUE, Carnegie Mellon University
ROBERT B. DUNBAR, Stanford University
LESLEY-ANN DUPIGNY-GIROUX, University of Vermont
EFI FOUFOULA-GEORGIU (NAE), University of California, Irvine
PETER C. FRUMHOFF, Union of Concerned Scientists
ROBERT KOPP, Rutgers University, The State University of New Jersey
RUBY LEUNG (NAE), Pacific Northwest National Laboratory
ZHANQING LI, University of Maryland
JONATHAN MARTIN, University of Wisconsin–Madison
AMY McGOVERN, Oklahoma State University
LINDA O. MEARNS, National Center for Atmospheric Research
JONATHAN A. PATZ (NAM), University of Wisconsin–Madison
J. MARSHALL SHEPHERD (NAS/NAE), University of Georgia
DAVID W. TITLEY, US Navy (Retired) and The Pennsylvania State University
ARADHNA TRIPATI, University of California, Los Angeles
ELKE U. WEBER (NAS), Princeton University

National Academies of Sciences, Engineering, and Medicine Staff

AMANDA STAUDT, Senior Board Director
APURVA DAVE, Senior Program Officer
APRIL MELVIN, Senior Program Officer
AMANDA PURCELL, Senior Program Officer
STEVEN STICHTER, Senior Program Officer
ALEX REICH, Program Officer
RACHEL SILVERN, Program Officer
MORGAN DISBROW-MONZ, Associate Program Officer
BRIDGET McGOVERN, Associate Program Officer
PATRICIA RAZAFINDRAMBININA, Associate Program Officer
HUGH WALPOLE, Associate Program Officer
RITA GASKINS, Administrative Coordinator
AMY MITSUMORI, Research Associate
ROB GREENWAY, Program Associate
KYLE ALDRIDGE, Senior Program Assistant
LINDSAY MOLLER, Senior Program Assistant
SABAH RANA, Senior Program Assistant
RACHEL SANCHEZ, Program Assistant

BOARD ON ENVIRONMENTAL CHANGE AND SOCIETY

KRIS EBI (*Chair*), University of Washington

BILAL M. AYYUB, University of Maryland, College Park

LISA DILLING, University of Colorado Boulder and Cooperative Institute for Research in
Environmental Sciences

KENNETH GILLINGHAM, Yale University (Emeritus)

LORI HUNTER, University of Colorado Boulder

KATHARINE L. JACOBS, Center for Climate Adaptation Science and Solutions and
University of Arizona

STEPHEN H. LINDER, University of Texas Health Science Center at Houston

GARY E. MACHLIS, Clemson University

MICHAEL A. MÉNDEZ, University of California, Irvine

ASEEM PRAKASH, University of Washington

BENJAMIN K. SOVACOOOL, Boston University

MICHAEL VANDENBERGH, Vanderbilt University

CATHY L. WHITLOCK (NAS), Montana State University

National Academies of Sciences, Engineering, and Medicine Staff

THOMAS THORNTON, Board Director

SITARA RAHIAB, Senior Program Officer

JOHN BEN SOILEAU, Program Officer

SHARON BRITT, Program Coordinator

HANNAH STEWART, Associate Program Officer

GRACE BETTS, Research Associate

Reviewers

This Consensus Study Report was reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise. The purpose of this independent review is to provide candid and critical comments that will assist the National Academies of Sciences, Engineering, and Medicine in making each published report as sound as possible and to ensure that it meets the institutional standards for quality, objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process.

We thank the following individuals for their review of this report:

KAREN AKERLOF, George Mason University
PHILIP ARDANUY, INNOVIM, LLC
ANA DIEZ ROUX (NAM), Drexel University
ALISON EAGLE, Environmental Defense Fund
TONYA GRAHAM, Geos Institute
ROBERT KOPP, Rutgers University
JULIE PULLEN, Propellor
JULIE RAYMOND-YAKOUBIAN, Kawerak, Inc.
LORETTA SINGLETARY, University of Nevada, Reno
CATHY WHITLOCK (NAS), Montana State University

Although the reviewers listed above provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations of this report, nor did they see the final draft before its release. The review of this report was overseen by **KAI LEE**, Owl of Minerva, LLC, and **ANTONIO BUSALACCHI (NAE)**, University Corporation for Atmospheric Research. They were responsible for making certain that an independent examination of this report was carried out in accordance with the standards of the National Academies and that all review comments were carefully considered. Responsibility for the final content rests entirely with the authoring committee and the National Academies.

Contents

Summary	1
1 Introduction	5
The Committee’s Approach to This Report, 6	
Report Roadmap, 7	
2 Overarching Comments and Recommendations	9
Notes of Praise, 9	
Addressing the Mandate in the Global Change Research Act of 1990, 10	
Recommendations for Consistent Structures, 12	
Additional Inconsistencies Between Chapters, 22	
Recommendations on Equity and Justice, 27	
Areas to Add Emphasis, 30	
3 Chapter Comments	35
Chapter 0: Front Matter, 35	
Chapter 1: Overview, 36	
Chapter 2: Climate Trends, 42	
Chapter 3: Earth System Processes, 47	
Chapter 4: Water, 53	
Chapter 5: Energy Supply, Delivery, and Demand, 62	
Chapter 6: Land Cover and Land-Use Change, 68	
Chapter 7: Forests, 74	
Chapter 8: Ecosystems, Ecosystem Services, and Biodiversity, 83	
Chapter 9: Coastal Effects, 89	
Chapter 10: Oceans and Marine Resources, 100	
Chapter 11: Agriculture, Food Systems, and Rural Communities, 103	
Chapter 12: Built Environment, Urban Systems, and Cities, 109	
Chapter 13: Transportation, 114	
Chapter 14: Air Quality, 118	
Chapter 15: Human Health, 121	
Chapter 16: Tribes and Indigenous Peoples, 128	
Chapter 17: Climate Effects on US International Interests, 133	
Chapter 18: Sector Interactions, Multiple Stressors, and Complex Systems, 141	
Chapter 19: Economics, 147	
Chapter 20: Social Systems and Justice, 152	
Chapter 21: Northeast, 155	
Chapter 22: Southeast, 162	
Chapter 23: US Caribbean, 165	
Chapter 24: Midwest, 170	
Chapter 25: Northern Great Plains, 177	

Chapter 26: Southern Great Plains, 183	
Chapter 27: Northwest, 187	
Chapter 28: Southwest, 194	
Chapter 29: Alaska, 202	
Chapter 30: Hawai‘i and US-Affiliated Pacific Islands, 207	
Chapter 31: Adaptation, 213	
Chapter 32: Mitigation, 218	
Focus on Compound and Complex Events, 227	
Focus on Western Wildfires, 230	
Focus on COVID-19 and Climate Change, 234	
Focus on Risks to Supply Chains, 236	
Focus on Blue Carbon, 238	
Appendix 3: Scenarios and Datasets, 240	
Appendix 4: Indicators, 240	
References	243
Appendix A Line-by-Line Comments	267
Appendix B Committee Member Biographical Sketches	325

Summary

The US Global Change Research Program (USGCRP) is mandated to develop an assessment of global change every four years or less. The Fifth National Climate Assessment (NCA5) is the latest in a series of sustained assessments that evaluate the state of global change science and analyze the wide range of impacts of climate change in the United States. The assessments represent a consensus-based view of the state of knowledge, relevant for policy and decision making.

The draft NCA5 report reviewed here addresses a wide range of topics of high importance to the United States and society more broadly, extending from human health and community well-being to the built environment, to businesses and economies, and to ecosystems and water resources. NCA5 is a unique opportunity to examine the impacts of current and projected climate change on each region of the United States. Hundreds of experts representing federal, state, and local governments; academia; non-governmental organizations; and the private sector developed the draft NCA5 report, with further input from community engagement events and public comment. The scale of collaboration is the largest for any National Climate Assessment (NCA) to date. The impressive and rich array of perspectives introduced through the NCA5 writing process provides an opportunity to develop a foundational climate change report that informs and highlights adaptation and mitigation efforts and serves as a valuable resource for broad audiences.

The National Academies of Sciences, Engineering, and Medicine convened an ad hoc Committee to Review the Draft Fifth National Climate Assessment (the “Committee”). The Committee is charged with providing a comprehensive, independent review of the draft NCA5 report, concurrent with the public comment period. In its review, the Committee evaluated the draft NCA5 report to determine whether it meets the requirements of the federal mandate; provides accurate information grounded in the scientific literature; and effectively communicates climate science, impacts, and responses for general audiences including the public, decision makers, and other stakeholders (see Chapter 1 of this report for the Committee’s complete Statement of Task). Chapter 2 of this report synthesizes the Committee’s overarching comments on the draft NCA5 report and makes recommendations for improvement. Chapter 3 provides detailed comments on each individual chapter of the draft NCA5 report, and Appendix A includes detailed line-by-line comments. The Committee’s approach to this review was to provide constructive comments and specific suggestions to strengthen the accuracy, consistency, credibility, and accessibility of the key messages and supporting text in the draft NCA5 report.

The Committee applauds the NCA5 authors for their outstanding job assembling, researching, and interpreting the vast knowledge of an extremely complex and rapidly changing topic—climate change impacts, adaptation, and mitigation in the United States. The Committee also commends the NCA process for its use of traceable accounts to accurately document the state of knowledge—including emerging and remaining gaps in knowledge—regarding the impacts of climate change. The draft NCA5 report gives significant attention to matters of equity and justice—a substantial and long-overdue improvement over past NCAs. The Committee appreciates the attention to evaluating climate change impacts and responses through the lens of equity and justice. The Committee also commends the NCA5 authors for identifying progress the United States has made in adapting to climate change, particularly providing examples of successful adaptations by local and tribal communities.

Clear and consistent structures support the ability of NCA5 to reach its target audiences effectively, thereby enhancing the credibility and usability of the report. In order for the draft NCA5 report to better provide a clear, thorough, and credible encapsulation of the knowledge base of the impacts of climate change on the United States, the Committee recommends that consistent structures be adopted to make the report accessible to the target audiences:

1. **Key message “labels” and “titles” should follow a common structure throughout the report.**
2. **The “message” part of each key message should have a consistent reading level, length, and voice throughout the report.**
3. **Confidence and likelihood statements should be used consistently for each claim across all key messages, and readers should be able to readily understand what is meant by confidence and likelihood.**
4. **A consistent framework for traceable accounts sections would better support the key messages and build consistency and credibility across chapters.**
5. **The introduction to each chapter should be consistent in length, depth of content, relationship to key messages, and voice; new terminology should also be introduced in a consistent manner.**

It is vital that key messages throughout the report are crafted consistently and carefully. Key messages should incorporate and express the knowledge base through the use of appropriate confidence and likelihood levels and be carefully written so that findings can be understood by broad audiences and not taken out of context. Special attention is needed to ensure confidence and likelihood statements convey important context to readers about claims made in the key messages. Similarly, traceable accounts provide credibility and transparency to each key message and associated text; thus, a framework is recommended to build consistency and credibility for this important section. While it is appropriate for the text supporting the key messages to look different from one chapter to another, consistent introductory sections would provide readers with the appropriate context and a roadmap to understand the rest of the chapter.

Overall, the Committee is impressed with the graphics throughout the draft NCA5 report. Considering that figures and boxes are opportunities to meaningfully convey information to the broadest possible audiences, the Committee recommends the following:

6. **All figures, figure captions, and figure citations should be consistent and self-contained.**
7. **Boxes within chapters should be used to highlight specific examples or to summarize or improve message accessibility.**

The Committee recommends making figures and their captions self-contained such that the reader can easily understand the key ideas related to the figure without reading the supporting chapter text. The Committee also suggests that figures adhere to basic principles of design, including through the use of consistent titles, colors, and symbols. The use and content of boxes could also be more effective if reserved for specific types of content (i.e., firsthand stories, examples, complex concepts, an important figure). When possible, boxes could be better utilized to communicate a message that is not clearly expressed in the main text or needs amplification.

In addition to the structural issues raised above, there are a number of other inconsistencies across the draft NCA5 report that pertain to the ways topics and terms are structured and discussed. While it is appropriate for chapter authors to design their chapters to meet specific topical needs, there are certain content areas that would benefit from more consistent treatment throughout the draft NCA5 report to strengthen the credibility of key messages and enhance clarity and readability:

- 8. The draft NCA5 report should be revised to address inconsistencies across chapters, including treatment of adaptation and mitigation, distinction between natural variability and climate change, use of scenarios, treatment of Focus On... Features, and the use of terminology.**
- 9. The draft NCA5 report should be revised to utilize and distinguish between the different use cases of sea-level rise projections and sea-level rise scenarios clearly and consistently.**
- 10. Individual chapters across the draft NCA5 report—particularly national and regional chapters—should be better integrated and cross-referenced.**

Where inconsistencies in structure and content between chapters cannot otherwise be resolved, the Front Matter could explain these differences. Overall, stronger cross-referencing and integration between chapters would reduce redundancies and inconsistencies, create more space for authors to expand on certain topics, and strengthen connections between national and regional topics.

The Committee commends the NCA5 authors for incorporating equity and justice into the report; however, there are opportunities to more intentionally and consistently integrate issues related to equity and justice throughout the report to highlight systemic interconnections. To that end, the Committee makes the following recommendations:

- 11. For consistency, chapter introductions should include context on equity and justice as related to the chapter topic. To move beyond general statements, different dimensions of justice, including distributional, procedural, recognition, and intergenerational justice, should be addressed as appropriate throughout the chapter text. Related gaps in the literature should be identified in the text and traceable accounts.**
- 12. A glossary of terms related to equity and justice should be adopted and/or developed to ensure consistent use of terminology across NCA5. Associated references should be provided.**
- 13. To provide equitable access to climate-related information across US communities, national chapters should include all US islands and territories in their figures and assessments whenever possible.**

Finally, in reviewing the draft NCA5 report as a whole, the Committee recommends more thorough attention should be given to certain topical areas:

- 14. Relatively more emphasis should be placed on the topics of: mitigation, adaptation successes and shortcomings, projected impacts of climate change, attribution of extreme events, and rural analysis.**

1

Introduction

The Global Change Research Act of 1990 mandates the US Global Change Research Program (USGCRP) develop an assessment of global change every four years or less. The Fifth National Climate Assessment (NCA5) is the latest in a series of sustained assessments that evaluate the state of global change science and analyze the wide range of impacts of climate change in the United States. The assessments represent a consensus-based view of the state of the science and, although they are relevant for policy and decision making, they do not prescribe policy interventions (Crimmins, 2022). The first National Climate Assessment (NCA) was produced in 2001 (National Assessment Synthesis Team, 2001), the second in 2009 (Karl et al., 2009), the third in 2014 (Melillo et al., 2014), and the fourth in two volumes—volume I in 2017 (USGCRP, 2017) and volume II in 2018 (USGCRP, 2018a).

The National Academies of Sciences, Engineering, and Medicine (the National Academies) have a long history of providing advice to USGCRP by conducting formal reviews of the NCAs, USGCRP strategic plans, and other USGCRP products (NASEM, 2017a). Foundational National Academies reviews of USGCRP programs include National Research Council (2003) and (2004). Recent examples of National Academies reviews include the draft Fourth National Climate Assessment (NASEM, 2018a; USGCRP, 2018a), the draft Climate Science Special Report (NASEM, 2017b; USGCRP, 2017), the draft Second State of the Carbon Cycle Report (NASEM, 2018b; USGCRP, 2018b), the draft Third National Climate Assessment (Melillo et al., 2014; NRC, 2013), and the draft assessment on the impacts of climate change on human health (NASEM, 2015; USGCRP, 2016).

These reviews are authored by ad hoc committees or by the Committee to Advise the USGCRP. Established in July 2011, the Committee to Advise the USGCRP provides broad, ongoing advice from across the National Academies to the USGCRP. It also serves as a point of contact through which USGCRP can gain access to expertise throughout the National Academies for advice on specific aspects of the program. The National Academies convened an ad hoc Committee to Review the Draft Fifth National Climate Assessment (the “Committee”). The Committee is charged with providing a comprehensive, independent review of the draft NCA5 report, concurrent with the public comment period. The complete Statement of Task for the Committee’s review is provided in Box 1-1.

A number of elements are new to NCA5. Compared to the Fourth NCA, the draft NCA5 report added chapters on economics (Chapter 19) and social systems and justice (Chapter 20) and divided the physical science chapter into two chapters (Chapter 2 on Climate Trends and Chapter 3 on Earth System Processes). Also new to NCA5 are five “Focus On... Features” on topics that span multiple chapters. The NCA5 author team is larger and more diverse, with more than 500 authors and technical contributors. The NCA5 authors have also placed particular emphasis on figures, science communication, equity and justice, and the development of a web-first format for the report.

There were several opportunities for public engagement with the development of the draft NCA5 report, including engagement workshops, a call for technical input, calls for comment on the draft prospectus and the annotated outline for the draft NCA5 report, and two calls for artwork.

BOX 1-1
Statement of Task

An ad hoc committee will conduct a review of the Draft Fifth National Climate Assessment, concurrent with the public comment period. The committee will incorporate diversity, equity, inclusion, and justice principles in its review. The committee's review will address the following questions about the draft report:

1. Does the draft assessment meet the requirements of Section 106 of the Global Change Research Act?
2. Do the key messages reflect current understanding about observed and projected impacts to the United States, the challenges, opportunities, and success stories for addressing risk, and identification of emerging issues related to climate change?
3. Does the draft assessment accurately reflect the peer-reviewed scientific literature or other source information cited, with a particular focus on literature since the last National Climate Assessment?
4. Does the draft assessment appropriately identify and provide sufficient context for embedded content, and does this content reflect current scientific understanding?
5. Are there any critical content areas missing from the draft assessment and not adequately addressed by embedded content or references?
6. Are the findings documented in a consistent, transparent, and credible way?
7. Is the draft assessment written at a technical level that is appropriate for the intended audience?
8. Are the draft assessment's key messages and graphics clear, internally consistent, and appropriate? Specifically, do they reflect supporting evidence, include an assessment of likelihood, and communicate effectively?
9. Are the data and analyses handled in a consistent, transparent, and credible manner? Are statistical methods applied appropriately?
10. What other significant improvements, if any, might be made in the draft assessment?

THE COMMITTEE'S APPROACH TO THIS REPORT

During fall 2022, the National Academies appointed the Committee, which is composed of 18 members who have expertise in climate change science, vulnerability, and adaptation in the regions and sectors covered in NCA5. Committee members were not authors of or technical contributors to the draft NCA5 report. The draft NCA5 report was released to both the Committee and the public on November 7, 2022. In addressing its tasks, the Committee met virtually three times from November to December 2022. The Committee held one open-session meeting to learn more about NCA5 and ask questions of the Director of the National Climate Assessment and other NCA5 authors. Individual chapters were reviewed by small teams of Committee members. In addition to chapter review teams, Committee members looked across the entire draft NCA5 report with particular attention to how well it addresses equity and justice and how clearly and accurately the report communicates the state of knowledge on climate change science. The Committee's review was restricted to figures that had cleared copyright by January 27, 2023, and did not include other elements not available to the Committee, including the Glossary that is currently under development. Following the standard National Academies' procedures, the Committee's draft report then underwent a rigorous process of external peer review before publication.

REPORT ROADMAP

This report serves as the Committee’s comprehensive review of the draft NCA5 report. After this brief introduction (Chapter 1), Chapter 2 synthesizes the Committee’s overarching comments on the draft NCA5 report and makes recommendations for improvement. These comments cover both the structure across and within chapters as well as content across the entire draft NCA5 report. Chapter 3 provides detailed comments on each individual chapter as well as the five Focus On... Features, the Front Matter, and Appendixes 3 and 4; comments closely follow the questions in the Committee’s Statement of Task (Box 1-1). The individual chapter reviews use a common structure with a summary followed by comments on the introduction, key message and supporting text language, traceable accounts, graphics and boxes, equity and justice, data and analyses, literature cited, and other recommended changes, as applicable. Appendix A includes detailed line-by-line comments on each chapter in the draft NCA5 report. The Committee’s approach to this review was to provide constructive comments and specific suggestions to strengthen the accuracy, consistency, credibility, and accessibility of the key messages and supporting text in the draft NCA5 report. The Committee recognizes that NCA5 authors have limitations regarding structure and length and this review is careful to suggest places to eliminate writing where the Committee also suggests adding material. In its review, the Committee uses the term “climate change” to refer to anthropogenic climate change.

The primary audiences of NCA5 are “decision makers” including federal agencies, local and state governments, tribes, health care providers, educators, business owners, and the media (Allison Crimmins, personal communication). In its review, the Committee thought carefully about the audiences for NCA5 while developing recommendations related to effective communication. Tailoring communication to specific audiences is one of the fundamental principles of strategic science communication (Besley and Dudo, 2022) and contributes to desirable audience outcomes (Bostrom et al., 2013). Considering the breadth of potential audiences and users of NCA5 requires authors to communicate findings in a way that enhances accessibility while maintaining accuracy. When assessing whether the draft NCA5 report was written at an appropriate technical level, the Committee focused on two different target audiences—a broad audience base and a more technical audience base. Specifically, the Committee assessed chapter introductions, key messages and associated text, and figures from the perspective of targeting the broadest possible audiences, while the Committee expected the traceable accounts to target more technical audiences (e.g., the scientific research community). The Committee also considered how broad audiences might use some parts of the report, such as key messages, boxes, and figures.

2

Overarching Comments and Recommendations

The Committee applauds the Fifth National Climate Assessment (NCA5) authors for an impeccably researched, assembled, and interpreted vast body of literature on an extremely complex and rapidly changing topic—climate change impacts, adaptation, and mitigation in the United States. This is no easy task and is increasingly challenging as the knowledge base on climate change (e.g., the literature, action on climate change mitigation and adaptation) has dramatically expanded in recent decades, particularly since the last National Climate Assessment (NCA) report was released in 2018. The Committee also commends the NCA process for the inclusion of traceable accounts sections at the end of each chapter to describe the process and rationale authors used to develop the chapter and reach consensus on key messages. These sections support the ability of the draft NCA5 report to accurately document the state of knowledge—including recent additions and remaining gaps in knowledge—regarding the impacts of climate change.

The Committee has many recommendations on how the draft NCA5 report can be revised to more clearly and credibly communicate its contents and add emphasis to better balance the state of knowledge on climate change. These recommendations are intended to support the overall goal of NCA5, which is to report on: the scientific understanding of climate change, how climate change already has and is expected to further affect the United States, and what can be done to mitigate and adapt to climate change. Before discussing the recommendations for revising the draft NCA5 report, the Committee outlines some of the many aspects of the report that deserve note and praise.

NOTES OF PRAISE

The draft NCA5 report gives significant attention to matters of equity and justice. This is a substantial and long-overdue improvement over past NCAs, and the Committee appreciates the attention to evaluating climate change impacts and responses through the lens of equity and justice. This attention to equity and justice is notable in many ways, including in the identification of overburdened communities, disproportionate consequences, and systemic drivers of vulnerability, particularly for tribal and other frontline communities in urban and rural areas. The Committee commends the NCA5 authors for using traditional knowledge in its assessment such as in Chapters 16 (Tribes and Indigenous Peoples), 29 (Alaska), and 30 (Hawai‘i and US-Affiliated Pacific Islands).

The Committee commends the NCA5 authors for identifying progress the United States has made in adapting to climate change, particularly at the state and local levels. The regional chapters review state-level adaptations and highlight promising examples of local-level adaptations, including actions of tribal communities. Chapter 31 (Adaptation) strikes the appropriate tone describing how adaptation measures to date appear to be insufficient to address the growing risks from climate change and that transformative adaptation as well as increased funding and technical support will be needed. Given the strong attention the report devotes to adaptation, there is an opportunity to give a similar treatment to mitigation actions, noted below.

Lastly, the draft NCA5 report has done a better job than previous NCAs of characterizing the Representative Concentration Pathway (RCP) scenarios used in recent Intergovernmental Panel on Climate Change (IPCC) assessments and NCAs. The use of terms such as “intermediate” and “very high” to characterize the RCPs better reflects the likelihood of these radiative forcing scenarios happening and makes these scenarios more accessible to general audiences. Consistent use of these more accessible terms beyond the introductory chapters would more clearly and effectively communicate the implications of each scenario throughout the report.

ADDRESSING THE MANDATE IN THE GLOBAL CHANGE RESEARCH ACT OF 1990

Overall, the Committee finds the draft NCA5 report addresses the mandate of Section 106 of the Global Change Research Act (GCRA) (Box 2-1). The draft NCA5 report integrates, evaluates, and interprets the science on climate change, and the Committee finds that the breadth of coverage of key climate change topics is impressive. The draft NCA5 report has done a masterful job pulling diverse information on the complex topic of global change together. In subsequent sections and in Chapter 3 of this report, the Committee offers specific comments on how the information base is interpreted and opportunities for improvement.

BOX 2-1

Global Change Research Act of 1990,^a Section 106. Scientific Assessment

On a periodic basis (not less frequently than every 4 years), the Council, through the Committee, shall prepare and submit to the President and the Congress an assessment which:

1. Integrates, evaluates, and interprets the findings of the Program and discusses the scientific uncertainties associated with such findings.
2. Analyzes the effects of global change on the natural environment, agriculture, energy production and use, land and water resources, transportation, human health and welfare, human social systems, and biological diversity.
3. Analyzes current trends in global change, both human-induced and natural, and projects major trends for the subsequent 25 to 100 years.

^a US Global Change Research Act of 1990, P.L. 101-606 (11/16/90), 104 Stat. 3096-3104.

Regarding subsection 1 of the GCRA, the draft NCA5 report addresses the state of knowledge about the science of climate change, including how climate change is already happening as a result of greenhouse gas (GHG) emissions and how the climate is projected to continue changing; impacts of climate change on sectors and regions of the United States; and how those impacts are projected to change in the future as a result of varying intensities of climate change mitigation and adaptation efforts. Although the Committee has recommendations on how to improve the draft NCA5 report, it is important to note that it is comprehensive, thorough, and well documented. In addition, although the Committee has recommendations on how to better integrate uncertainties into the text supporting key messages, overall, the NCA5

authors have made a substantial effort to assess the state of knowledge and report scientific uncertainties associated with their report findings, providing credibility and transparency to the report.

Consistent with previous NCAs, the draft NCA5 report focuses on climate change and does not focus on other global change issues. In many cases, the draft NCA5 report analyzes the interactions of climate change with other global change issues—particularly how other global changes intensify the effects of climate change. For example, Chapter 6 (Land Cover and Land-Use Change) considers how land cover and land-use change can lower the resilience of ecosystems and agriculture to climate change impacts. Chapter 8 (Ecosystems, Ecosystem Services, and Biodiversity) effectively discusses the interactions of climate change with non-climate stressors including land-use change, urbanization, pollution, and overharvesting, and Chapter 7 (Forests) discusses the impact of fire and land-use change on the terrestrial carbon sink. Additionally, some regional chapters discuss other changes that have important implications for local vulnerability. Chapter 29 (Alaska) touches on non-climate stressors, including food insecurity, limited employment, and cost of living (Key Message 29.7), and Chapter 22 (Southeast) discusses urbanization in the region and how it changes exposure to climate change. However, important global change trends are not discussed in other regional and national chapters. The Focus on Compound and Complex Events defines “complex events” as those where climatic and non-climatic stressors interact in ways that exacerbate climate hazards, but these events are not addressed throughout the Focus. Other changes, such as baseline conditions, may also be important to discuss to better understand how the vulnerability of regions and sectors are changing. For example, the state of the public health system is a key factor affecting the vulnerability of the health sector to climate change but is not discussed in Chapter 15 (Human Health). Overall, the draft NCA5 report could more intentionally integrate how climate change interacts with the full suite of global changes and non-climate stressors.

The draft NCA5 report covers all of the topics enumerated in subsection 2 of the GCRA, including individual chapters on climate change impacts on natural ecosystems and biological diversity (Chapter 8 [Ecosystems, Ecosystem Services, and Biodiversity]), agriculture (Chapter 11 [Agriculture, Food Systems, and Rural Communities]), energy production and use (Chapter 5 [Energy Supply, Delivery, and Demand]), land-use (Chapter 6 [Land Cover and Land-Use Change]), water resources (Chapter 4 [Water]), transportation (Chapter 13 [Transportation]), human health (Chapter 15 [Human Health]), and social systems (Chapter 20 [Social Systems and Justice]), and many other chapters including the regional chapters touch on these issues as well. Several chapters are highly relevant to the scope of the GCRA, though not enumerated in subsection 2, including Chapter 7 (Forests), Chapter 12 (Built Environment, Urban Systems, and Cities), and Chapter 17 (Climate Effects on US International Interests).

Even though NCA5 has a chapter on climate trends (Chapter 2), projections of impacts 25 years to 100 years into the future—as noted in subsection 3 of the GCRA—are not consistently provided throughout the draft NCA5 report. For example, Chapter 15 (Human Health) says little about the projected impacts of climate change on human health. There is some discussion of projected impacts by mid-century and end of the century in most national and regional chapters. However, the Committee did not note any projections or discussions of impacts 100 years from the present (i.e., 2025), though this is likely due to the focus on estimating impacts out to the end of the 21st century in the scientific literature. This has been the case for decades (e.g., National Assessment Synthesis Team, 2001), but as time has passed, the end of the century is less than 100 years after the publication of NCAs, and therefore does not

satisfy subsection 3 of the GCRA. As described in the Committee’s review of Appendix 3 and in Recommendation 8 below, there are difficulties in extending projections beyond 2100, but where this information is available, it should be included. Where there are gaps in the literature in which projections 100 years in the future have not been considered, these gaps should be noted in the “Major Uncertainties and Research Gaps” section of individual chapter traceable accounts.

Some chapters (e.g., Chapter 15 [Human Health]) present future impacts and risks as a function of global warming levels rather than tying them to specific emission scenarios and time frames; both can be effective ways to communicate projections and vulnerabilities into the future. For example, Figure 4.7 in Chapter 4 (Water) displays projected mid-21st century changes in runoff under the “intermediate” emissions scenario, while Figure 8.3 in Chapter 8 (Ecosystems, Ecosystem Services, and Biodiversity), identifies increases in global mean temperature that could lead to a suite of adverse global ecological impacts. Chapters could more consistently discuss first the diagnostic state of the science on impacts (i.e., past and current, including attribution of impacts to climate change) and then the forward-looking prognostic state of science on future impacts, rather than frequently switching between discussions of historical and projected changes.

RECOMMENDATIONS FOR CONSISTENT STRUCTURES

Clear and consistent structures support NCA5 in reaching its target audiences effectively, thereby enhancing the credibility and usability of the report. In the section that follows, the Committee outlines recommendations that address the structure of chapters across the entire draft NCA5 report. Overall, the Committee recommends that consistent structures be followed for key messages, traceable accounts, chapter introductions, and figures. These recommendations considered together would improve the readability of the draft NCA5 report for the range of audiences described in Chapter 1 of this report. Additionally, this section notes a number of content inconsistencies across chapters and provides recommendations for remedies.

Key Messages

Key messages form the backbone of NCA5 and should capture the state of knowledge around climate change and identify important research gaps and possible next steps for advancing the knowledge base. Therefore, it is vital that key messages throughout the report are crafted consistently and carefully. Key messages provide an opportunity for NCA5 to provide credible, salient, and tailored information to audiences in ways that are not policy prescriptive (Farrell and Jäger, 2006). While challenging to write, key messages should incorporate and express the knowledge base through the use of appropriate confidence and likelihood levels and careful writing of findings that can be understood by broad audiences and not taken out of context. As they are currently written, there is significant variation in the structure of the key messages throughout the draft NCA5 report. NCA5 authors may consider the key messages as having three parts: the label (i.e., Key Message 2.1); title (i.e., Climate Is Changing and Scientists Understand Why); and message (see Box 2-2).

BOX 2-2**Anatomy of the Fifth National Climate Assessment (NCA5) Key Message**

This box shows an example key message from Chapter 5 (Energy Supply, Delivery, and Demand) of the draft NCA5 report to illustrate the different components of an effective key message. Colors indicate different components of the key message and the terminology the Committee will use to discuss how to improve the format and content of the key messages throughout this report.

Key Message 5.2. Compounding Factors Affect Energy System and Community Vulnerabilities
Interconnected effects of changes in technologies, policies, and markets increase the potential vulnerabilities of energy systems and communities to climate change and extreme weather (*likely, high confidence*). Compounding and cascading hazards related to energy systems and additional stressors such as cyberthreats and pandemics create risks for all but disproportionately affect underserved and overburdened communities (*likely, high confidence*).

Expanded mitigation and adaptation activities for energy systems include upgraded grid design, hardening of energy infrastructure, and vegetation management to reduce wildfire risk (Moreno et al. 2022; Vazquez et al. 2022) ...

Orange = label

Green = title

Blue = key message

Purple = confidence/likelihood rating

Red = supporting text

Recommendation 1: Key message “labels” and “titles” should follow a common structure throughout the report.

Key message titles should communicate enough information to engage readers and use a consistent hierarchy for the information presented, following best practices in design (Seddon and Waterhouse, 2009). Therefore, the titles would be more effective if written as short, informative statements—instead of just one or two words—that convey a simplified but accurate message. Key message titles in Chapter 5 (Energy Supply, Delivery, and Demand) all convey information—for example, Key Message 5.2, “Compounding Factors Affect Energy System and Community Vulnerabilities.” In contrast, in Chapter 17 (Climate Effects on US International Interests), the title of Key Message 17.2 could be rephrased from “National Security” to “Destabilization of Other Countries by Climate Change Affects US National Security.” Additionally, the Committee appreciates that authors include the words “Key Message” in each label to cue to audiences of what they are reading and its importance. If the authors write titles as brief statements, they should be carefully written to be consistent with the knowledge base in the key message and traceable accounts. The Committee provides more specific suggestions for many of the key message titles in Chapter 3 of this report.

Recommendation 2: The “message” part of each key message should have a consistent reading level, length, and voice throughout the report.

The message part of each key message (see Box 2-2) varies significantly across the draft NCA5 report. The messages are the text that will be read and quoted the most by a wide range of audiences, including those that lack familiarity with the jargon and technical language of climate change; thus, the messages should be the most accessible parts of the report. Each message should be written simply and clearly, using short, uncomplicated sentences, omitting as much specialized jargon or needlessly complex language as possible (e.g., choose a word like “use” over “utilize”) (Somerville and Hassol, 2011; van der Linden et al., 2015). This practice will ensure comprehension by broad audiences. It is similarly recommended by major medical associations that health communication materials target their intended audiences and use appropriate language for broad comprehension (Badarudeen and Subharwal, 2010). The messages also vary in length, ranging from one sentence to more than five sentences. The NCA5 authors may consider selecting a range for a number of words or sentences to standardize key messages so that they are a consistent length. Because of the web-first format, the authors could consider consulting with designers on the best length.

The messages would be more effectively communicated if they were more balanced; some are very broad, and some are very specific. On the one hand, broad messages can seem unclear or not specific enough (e.g., Key Message 4.1, 15.3, 17.1, 18.1, 21.1, 25.4, 28.1). For example, Key Message 28.2 includes “disproportionate” with no explanation of its meaning in the context of the key message. On the other hand, specific messages often have too much jargon and technical language. For example, Key Message 6.3 uses technical phrases such as “crop yield improvements,” “animal-sourced foods,” “agriculture system resilience,” and “biomass crop cultivation” that could be simplified to language that could be more easily understood by general audiences (Somerville and Hassol, 2011). Key Message 28.4¹ is an example of a key message that says a lot but successfully uses plain language. The authors should also carefully consider the use of terms that can be imprecise, such as “historically,” “already,” and “currently,” ensuring that they are used in consistent, accurate ways across key messages. Many language issues occur across multiple chapters, and NCA5 authors may find it useful to look at the full list of key messages together to ensure that terms are being used harmoniously.

When possible, messages and titles should use the active voice (i.e., subject followed by a verb followed by the object of the verb) over the passive voice (i.e., object followed by a verb with or without a subject). Passive voice can be hard for a reader to understand because there is a less clear relationship between the subject and verb, making the relationship between the confidence/likelihood rating and climate impact unclear.² For example, in Chapter 1 (Overview), the section 1.5 header, “Deep cuts in emissions would be required to meet national commitments” could be re-phrased to demonstrate who or what is making deep cuts in emissions

¹ Key Message 28.4. Demographics and Human Health. Increases in extreme heat, drought, and wildfire activity are negatively impacting the physical health Southwest residents (*high confidence*). Climate change is also shaping the demographics of the region by spurring the migration of people, primarily from Central America to the Southwest (*medium confidence*). Individuals particularly vulnerable to increasing climate change impacts include the elderly, outdoor workers, and people with low income (*high confidence*). Local, state, and federal adaptation initiatives are working to respond to these climatic and demographic changes and help people and communities become more resilient (*medium confidence*).

² See https://owl.purdue.edu/owl/general_writing/academic_writing/active_and_passive_voice/active_versus_passive_voice.html.

using active voice. For example, the section header could be revised to: “Local, state, federal, tribal, and Indigenous communities are pursuing mitigation actions that reduce emissions across the country.” However, in using an active voice, NCA5 authors should be careful not to make statements policy prescriptive.

Additionally, some messages use a first-person voice (e.g., “Our Future,” Key Message 29.7; “We Know How to Drastically Reduce Emissions,” Key Message 32.2). In writing, the first-person point of view is used to tell a story from the author’s perspective. Because this is an assessment and review of the state of knowledge rather than original research where the authors could use the first-person to explain their results (i.e., “our findings suggest”), the Committee suggests NCA5 authors avoid first-person language. The Committee also encourages authors to avoid first-person language because it is unclear who the “our” or “we” refers to. It is also important to carefully replace first person language when rewriting these statements rather than simply using encompassing phrases such as “people in the US,” because that can also be inaccurate. Instead of using first-person language, where social science is available to support the key message, references to specific groups of people may be an acceptable replacement. Otherwise, the authors may consider selecting a more generic term such as “people” or “Americans,” but this should be defined in the beginning of the report (i.e., Americans could reference anyone living in the United States or may only refer to citizens, problematically excluding some people who also live in the United States but who are not citizens, such as undocumented immigrants).

Additionally, authors should pay special attention to statements that may be perceived as policy prescriptive or advocating for a specific position, such as declarative statements that may not be adequately supported. In general, evidence that is policy relevant should be emphasized and statements that are normative should be deemphasized. For example, in Chapter 2 (Climate Trends), a subsection in Key Message 2.3 is titled, “The Nation Has No Choice But to Adapt to a Changing Climate” and Key Message 31.3 states “To minimize the potential for adaptation actions to benefit some at the expense of others, adaptation processes must emphasize collaboration, centralize equity and justice, and incorporate a wide range of values and knowledge sources.” These statements should be rephrased so as not to be perceived as recommending certain policies or conveying a level of certainty not reflective of US policy. For example, the subsection in Chapter 2 (Climate Trends) could be re-phrased: “Adaptation can offset the adverse effects of climate change.”

Regarding the text supporting the key messages, the key message should drive the supporting discussion, not the other way around. Many key messages read as though they were distilled after the supporting text was drafted. Instead, the key message should include the key points that reflect the most important or new findings for each chapter. The supporting text should support the entire key message, including providing context and noting uncertainties, as appropriate, that can be elaborated on in the traceable accounts. Attention is needed to ensure text supporting the key messages adequately achieves these goals consistently across NCA5.

Recommendation 3: Confidence and likelihood statements should be used consistently for each claim across all key messages, and readers should be able to readily understand what is meant by confidence and likelihood.

Confidence and likelihood statements convey important context to readers about the claim being made. Confidence is intended to be a *qualitative* statement based on the amount and

consistency of information available (i.e., the weight of evidence). Likelihood is intended to be a *quantitative* statement based on observations and model projections or an assessment of such *quantitative* information across sources (i.e., the probability that an impact has happened, is happening, or will happen). It is often unclear whether the NCA5 authors distinguish between the qualitative versus quantitative natures of the two types of assessments.

In general, confidence and likelihood definitions should be provided for general audiences in the Front Matter, in both written and numerical format (Budescu et al., 2014) and consistently assigned in each key message across NCA5. Each claim in the key message should include confidence at minimum and likelihood if—and only if—a quantitative assessment of probability can be made from the source material. Presently, some messages make multiple claims, but do not include confidence and likelihood at all or only include one statement of confidence/likelihood at the end of the message. This leaves the reader to wonder if the rating is applied to one claim, all claims, or just the most recent claim in the message. The draft NCA5 report in general seldom includes likelihood statements—these should be consistently considered across the document so that the lack of likelihood statements reflects the threshold defined in the Front Matter rather than an oversight. Box 2-3 provides an example of a successful use of confidence/likelihood statements and an example of a key message where the use of confidence/likelihood statements could be improved.

Additionally, likelihood statements are often provided without a corresponding explanation of quantitative support in traceable accounts sections. The likelihood statements correspond to specific probability ranges per the definitions provided in the Front Matter, which require care to justify the difference between levels of likelihood (e.g., *very likely* at >90% probability versus *likely* at >66% probability). Expert judgment can be part of the likelihood assessment, but the assessment should be based on more than belief, and the basis for such quantitative judgments should be adequately described in the traceable accounts. When quantitative likelihood assessment is not possible, it is preferable to provide only a confidence statement consistent with the knowledge base. In some cases, the knowledge base is limited or emerging, and this should be reflected in the confidence language and further expounded on in the traceable accounts. Because general audiences may only read the main text and not the more technical traceable accounts, it may also be appropriate to highlight key uncertainties briefly in the text supporting the key messages. Specifically, providing uncertainty or knowledge gaps with scientific claims makes the information more useful to decision makers and increases transparency, which can contribute to trustworthiness.

In some cases, the draft NCA5 report ascribes likelihood language to findings that are not in dispute (i.e., where the likelihood probability, based on the knowledge base, is greater than 99%). In such cases, the Committee suggests NCA5 authors follow the IPCC Sixth Assessment Report (AR6) language to classify these findings as “unequivocal” or “established fact” rather than “very high confidence.” For example, Key Message 2.1 states, “It is virtually certain that human activities have increased atmospheric levels of carbon dioxide and other greenhouse gases (*very high confidence*)” whereas IPCC AR6 states: “Observed increases in well-mixed greenhouse gas (GHG) concentrations since around 1750 are unequivocally caused by human activities” (IPCC, 2021a). The use of term “unequivocal” is appropriate when discussing facts where there is no doubt regarding the findings.

The language that scientists use to describe uncertainty, including the words “confidence” and “likelihood,” is jargon. It is the specialized language of science and the words confidence and likelihood have different meanings and interpretations in everyday use (Somerville and

BOX 2-3**Example Confidence and Likelihood Statements from Key Messages**

Good Example: Each claim includes an associated confidence/likelihood statement:

The Northern Great Plains is experiencing unprecedented extremes related to changes in climate, including severe droughts (*likely, high confidence*), increases in hail frequency and size (*medium confidence*), floods (*very likely, high confidence*), and wildfire (*likely, high confidence*), with alterations in plant community and crop growth (*very likely, very high confidence*). (Key Message 25.1)

Needs Improvement: Multiple claims are listed in the first sentence, but there is no confidence/likelihood associated with the claims. The reader is left to determine if *Very Likely, Very High Confidence* relates to all claims in the key message or only the last claim:

Climate change is already harming human physical, mental, and spiritual health through increasing frequency and intensity of extreme events, increasing cases of infectious and vector-borne diseases, and declines in food and water security. Climate-related hazards will continue to grow, increasing morbidity and mortality across all regions of the United States. (*Very Likely, Very High Confidence*) (Key Message 15.1)

Hassol, 2011). In the Front Matter, the concepts of confidence and likelihood could be expanded somewhat to make them more accessible to readers unfamiliar with this language based on results from Budescu et al. (2014). The authors may also consider including a visual representation of confidence and likelihood, to supplement the text and numerical definitions in the Front Matter (Kause et al., 2022; Mastrandrea et al., 2010). The IPCC report is a similarly technical report, so simply presenting these terms and definitions with reference to the IPCC report is insufficient. Authors may consider a brief explanation about the nature of science, and how a single study or finding may advance understandings, that repeated replications of that work, scrutiny by the community of experts, and the convergence of expert agreement of particular findings and claims increase confidence in those understandings (Oreskes, 2021). This need not be extensive because that work has been done elsewhere, but this brief context is important for a less technical reader. In the web design, NCA5 authors may consider including definitions of confidence or likelihood ratings when the mouse arrow hovers over the phrase to remind readers of the meaning of these terms or navigate back to the Front Matter. Additionally, authors may consider including the standard definitions of confidence and likelihood at the beginning of each chapter as a standalone section. Many readers may never read the Front Matter where these terms are defined.

Traceable Accounts

Recommendation 4: A consistent framework for traceable accounts sections would better support the key messages and build consistency and credibility across chapters.

Traceable accounts written for each key message are an essential component of NCA5, providing both credibility and transparency to each key message and associated text and, therefore, the report. Overall, the traceable accounts include information about the state of knowledge and uncertainties that strengthen the quality of NCA5. The Committee's review of the traceable accounts emphasized, to the extent possible, whether the evidence presented for each key message consistently and adequately supported the assigned confidence and likelihood designations and the associated text rather than rigorously assessing the credibility of the determinations made by the authors. The Committee commends the use of confidence and likelihood statements consistent with the IPCC Fifth Assessment Report (AR5) definitions; however, there are significant inconsistencies in the traceable accounts sections across chapters, both in structure and how the evidence is presented. Chapter-specific comments are presented in Chapter 3 of this report, but here the Committee notes some of the major inconsistencies and provides recommendations to build a framework for NCA5 authors as they revise the traceable accounts sections.

Overall, the traceable accounts are appropriately written at a more technical level than the rest of the report and summarily discuss the literature base for their key messages. However, traceable accounts sections inconsistently satisfy their intended purpose, as defined by USGCRP (2018a): to detail *how* the authors arrived at their confidence and likelihood statements, and *what* evidence was used. The process for writing the traceable accounts is an analytical one about the state of the science in which authors should apply robust evidence (i.e., literature cited) to justify both the confidence and *likelihood* assigned to each statement within each key message. Thus, within the traceable accounts section, broad statements about the literature do not suffice and should be removed, citations should be included, and the substantive scope of the traceable accounts should be limited to the scope of the main text of the chapter. Additionally, where in the supporting text, authors are only able to make brief statements with a citation due to chapter word limits, they may provide greater depth in the traceable accounts, expanding on the main text to include additional context and discussion, specifically describing how that detail, nuance, or gap in understanding factored into the confidence and likelihood rating. For example, a discussion of which projections were and were not available for the chapter authors to consider and an explanation of model uncertainties are appropriate to include in the traceable accounts. There are many dense and technical passages in the text supporting the key messages that may be better suited for traceable accounts sections to enhance the readability of the main text (e.g., the text describing advances in the understanding of equilibrium climate sensitivity in Chapter 3 [Earth System Processes], pages 3-9 to 3-10).

There are many instances across the draft NCA5 report where traceable accounts sections do not provide any citations to support their statements (e.g., Chapters 4 [Water], 21 [Northeast], and 23 [US Caribbean]) and/or use broad statements such as “authors used their collective expertise and weighed the overall literature” to reach conclusions (e.g., Chapters 17 [Climate Effects on US International Interests], 23 [US Caribbean], and 25 [Northern Great Plains]). This kind of broad statement is descriptive of the process used to synthesize the literature and is not a substitute for identifying the literature (and should, likewise, be removed), nor does it provide sufficient detail required or support for the key messages. Section 106 of the GCRA does not require a summary report of the authors' collective expertise but rather an integration, evaluation, and assessment of the credible scientific base. It is appropriate for process details to be included; however, this should be done in a consistent way (e.g., some chapters provide a list of authors' expertise while others do not). Traceable accounts sections should be revised to

demonstrate *which* references support *each* confidence and likelihood statement under each key message. Examples of thoroughly written traceable accounts can be found in Chapter 5 of the Climate and Health Assessment, Vector-Borne Diseases (Beard et al., 2016) or the Energy Chapter of the Fourth National Climate Assessment (NCA4) (USGCRP, 2018a). In the draft NCA5 report, the traceable accounts for Chapter 19 (Economics) are strong overall, though there is room for improvement in the use of citations, described in Chapter 3 of this report.

The Committee recommends the following structure for traceable accounts that could be used throughout NCA5:

- Provide the full key message at the start of each traceable account.
- Summarize *which* references support each confidence and likelihood claim.
 - Include citations in “Description of Evidence Base.”
 - Include citations to “Major Uncertainties and Research Gaps.”
- Include a “therefore” statement describing *why* authors designated confidence and likelihood findings. Authors should describe *why* the confidence is not lessened due to research gaps *and* cite literature that supports this decision *only* if that literature is cited in the main text.
 - Include citations to “Description of Confidence and Likelihood,” if relevant.

Chapter Introductions

Recommendation 5: The introduction to each chapter should be consistent in length, depth of content, relationship to key messages, and voice; new terminology should also be introduced in a consistent manner.

NCA5 authors should assume that readers will read chapters that they are interested in without reading the Front Matter, Chapter 1 (Overview), or other introductory material. In general, the introduction section of the chapter should provide the reader with a brief background and context on the chapter theme and its relevance to climate change, a brief statement about what was covered in NCA4 and what new knowledge is being added in NCA5—including the key messages—and what the chapter will not cover. While it is appropriate for the text supporting the key messages to look different from one chapter to another, consistent introductory sections would provide readers with the appropriate context and a roadmap to understand the rest of the chapter. The consistent inclusion of sub-headers throughout chapters could also help to support this goal.

Many of the chapter introductions would benefit from a high-level introductory sentence to explain why climate change is relevant to the chapter’s topic or themes. In most introductory paragraphs, it is not explicit how the introduction section is related to the key messages. In introducing a chapter’s contents, the introduction should not read as an abstract of the chapter (e.g., Chapters 2 [Climate Trends], 4 [Water], and 28 [Southwest]). Chapter authors could consider using a model like Chapter 17 (Climate Effects on US International Interests) where the introduction is directly related to the key messages and key message titles are in parenthesis. Chapter 29 (Alaska) also provides a successful example that includes a table of the key messages with examples of climate drivers/impacts and responses; this type of summary or roadmap could be replicated in other chapters. In addition, chapter introductions should explicitly note what

topics are covered in the chapter and what topics are not. For example, Chapter 19 (Economics) does not discuss the economics of mitigation, and Chapter 17 (Climate Effects on US International Interests) does not review the international impacts of climate change—these choices should be explained in the introductions.

Introductory sections vary widely with respect to the use of technical language and could better engage the target audiences if they were less technical. The Committee highlights chapter-specific instances where jargon is used in Chapter 3 of this report. Similarly, when introducing new or complicated terms, authors should assume readers are encountering them for the first time, including seemingly basic terms (e.g., adaptation, mitigation). For commonly used terms across the whole report, a consistent definition should be selected and used throughout and referenced in the glossary currently under development for the final report but not available in the draft NCA5 report. For example, Chapter 31 (Adaptation) details the choice of “adaptation” over the commonly used “resilience” whereas “resilience” is used in many other chapters. Chapter 20 (Social Systems and Justice) uses “overburdened communities” over other terms frequently used in the report, such as “marginalized” or “underrepresented.” The NCA5 authors should make decisions about commonly used terms and use them consistently throughout the report. In the web design, rollover definitions could be provided for common phrases or words that are defined in the glossary.

The introductions to each chapter also use in-text citations and figures inconsistently. While figures may be more appropriate for some chapter introductions over others, there are opportunities to build consistency—for example, all regional chapters could include a map of the region with place names and locations referenced throughout the chapter. Introductions that use figures could consistently place them at the end of the section rather than in the middle because they are typically short sections. The NCA5 authors may also consider a word range for the introduction sections so that they are all roughly the same length throughout the report. The NCA5 authors should expand upon the glossary definitions in the chapter when the additional context or an expanded definition is needed to present a more precise definition tailored to the chapter readers.

Graphics and Boxes

Recommendation 6: All figures, figure captions, and figure citations should be consistent and self-contained.

Overall, the Committee is impressed with the graphics throughout the draft NCA5 report and understands that many graphics are still being designed or were unavailable to review due to the timing of copyright clearances. As the NCA5 authors make revisions, the Committee suggests they consider that many readers will only look at the figures and read the captions and may download and use the figures for a range of uses (e.g., reports, power points, lectures). Therefore, the Committee recommends making graphics self-contained such that the reader can easily understand the key ideas related to the figure without looking in the text. On the other hand, many figures are not adequately discussed in the body of the chapters and are at most pointed to in a parenthetical or not at all. All figures should be integrated meaningfully into the text to justify their inclusion in the chapter.

Based on recommendations by Gerst et al. (2021), Harold et al. (2016), and Rougier et al. (2014), the Committee encourages authors to ensure that each figure adheres to some basic principles of design and include at a minimum:

- Consistent use of titles;
- Legible text;
- Use of color and contrast, accessible to people who have colorblindness;
- Legend, if applicable;
- Sufficiently detailed caption; and
- Reference to the figure source(s), if applicable

To expand on the checklist above, there are many opportunities to introduce more consistency across the figures throughout the report. Furthermore, Gerst et al. (2021) explains how to improve many NCA figures based on experimental studies. Regarding embedded figure titles, NCA5 authors could consider choosing a consistent format for titles and making sure titles above and embedded in figures match. Regarding the color palette, the NCA5 authors could consider a consistent palette across the report figures, and if possible, use colors consistently to communicate particular ideas (i.e., ensure icons related to water are the same shade of blue). Regarding symbols and icons, NCA5 authors could consider adopting a similar style of icons across the report, and use them consistently (e.g., a fish icon representing fisheries in one figure will be the same fish icon representing fisheries in another graphic) and define these icons using legends in individual figures, where appropriate.

Figure caption length and amount of detail varies greatly across the report. Captions should sufficiently communicate the key ideas in the figure, explaining to the reader the important trends, takeaway points, data sources, or other information to inform readers on how the figure was created and how it should be read (Rougier et al., 2014). Captions should begin with a nontechnical explanation of what the figure shows and then, to a limited extent, the technical underpinnings of the figure. Especially in the case of a schematic illustration—a type of figure that presents a scene or story with text boxes or callouts of important facts—the captions should have sufficient references to the source material used to create the figure (Perra and Brinkman, 2021). Many (e.g., Figures 10.5, 11.5) only list the agencies or organizations that created the data or figure, making it difficult for audiences to identify the source for a claim communicated by, or data used, to generate a figure. In addition, captions should always include dates of the data or information being presented. The web version of the report could use hover-over popups to include more technical underpinnings of the figure.

The draft NCA5 report uses maps throughout to communicate a lot of information. Consistent with the recommendation about icons, the Committee suggests the report use consistent map features (e.g., colors and symbols) so that readers can easily understand any map they see in the report. Special attention is needed to establish a consistent arrangement of the contiguous states, Alaska, Hawai‘i and the US-Affiliated Pacific Islands, and the US Caribbean (Puerto Rico and the US Virgin Islands) on maps to ensure the full geographic domain of NCA5 is depicted. In the draft NCA5 report, Alaska and Hawai‘i are placed on maps in various locations (e.g., sometimes in their geographically accurate locations and sometimes below Florida), and in some cases, are not included at all. The US Caribbean is rarely included. If a geographic region is omitted, there should be an explanation in the caption as to why (e.g., no data). Additionally, there are issues related to scale with Alaska, Hawai‘i, the US-Affiliated

Pacific Islands, and the US Caribbean, and when that is the case, appendixes could be used for maps that are too small or out of scale. Gerst et al. (2021) should also be referenced for guidance on developing maps.

Recommendation 7: Boxes within chapters should be used to highlight specific examples or to summarize or improve message accessibility.

The use and content of boxes in chapters varies considerably across the draft NCA5 report. Boxes could be more effective if reserved for specific types of content (e.g., firsthand stories, examples, complex concepts, an important figure, or to summarize or otherwise improve message accessibility) in order to highlight specific items and/or deliver content more rapidly. Assessments of this nature inevitably provide a high-level summary of the state of the science, which can be rather abstract. Boxes are an opportunity to provide specific examples that can help readers connect the material to their everyday lives or policies and decisions they may hear about on the news, thus reducing the psychological distance (van der Linden et al., 2015). At the same time, boxes should at least mention their connection to climate change and related discussions in the chapters—for example, Boxes 28.2 and 4.3 do not mention the role of climate change.

When possible, boxes could be better utilized to communicate a message that is not clearly expressed in the main text or needs amplification. Boxes should include the relevant who, what, when, where, why, and how to provide a more tangible connection for readers. For example, Boxes 14.1 and 18.1 both tell compelling stories with data. Chapter 29 (Alaska) has many boxes with firsthand accounts from residents, which are excellent for making abstract phenomena more concrete and integrating Indigenous knowledge, but could be enhanced with some additional information (i.e., a description or graph showing the climate trend) and context (i.e., a few introductory sentences to describe the setting).

ADDITIONAL INCONSISTENCIES BETWEEN CHAPTERS

In addition to the structural issues raised above, there are a number of other inconsistencies across the draft NCA5 report that pertain to the ways topics and terms are structured and discussed. As a web-first report, it is unlikely NCA5 will be read by audiences cover-to-cover; thus, it is appropriate for chapter authors to design their chapters to meet their specific topical needs. However, there are certain content areas, described below, that would benefit from more consistent treatment throughout the draft NCA5 report to strengthen the credibility of key messages and enhance clarity and readability. Where inconsistencies in structure and content between chapters cannot otherwise be resolved, the Front Matter could explain these differences (e.g., the structure of each chapter was decided by the chapter authors). In the section below, the Committee outlines specific inconsistencies that stood out and, if resolved, would improve the draft NCA5 report.

Recommendation 8: The draft NCA5 report should be revised to address inconsistencies across chapters, including treatment of adaptation and mitigation, distinction between natural variability and climate change, use of scenarios, treatment of Focus On... Features, and the use of terminology.

Treatment of Adaptation and Mitigation

Adaptation and mitigation are not treated consistently across chapters. Adaptation is a major topic in all chapters, except in Chapter 32 (Mitigation), but it is not addressed in a consistent manner (e.g., sometimes together with mitigation). For example, in Chapter 7 (Forests), Key Message 7.3 focuses on adaptation, while Chapter 12 (Built Environment, Urban Systems, and Cities) has Key Message 12.3 on mitigation and adaptation measures in the built environment. Both sectors have GHG emissions or removals and are affected by climate change and thus address both mitigation and adaptation. Regional chapters in particular inconsistently include mitigation in key messages. There are also inconsistencies in how the regional chapters describe adaptation efforts or obscure what adaptation means by using examples such as forest management. Some chapters, such as Chapters 21 (Northeast) and 25 (Northern Great Plains), have key messages on adaptation, while most other regional chapters discuss adaptation within sectors and themes. Mitigation is sometimes mentioned together with adaptation, but examples used are typically only related to adaptation (e.g., Chapters 15 [Human Health], 21 [Northeast]). Often, chapter key messages include adaptation but omit discussions of mitigation entirely (e.g., Chapters 25 [Northern Great Plains], 16 [Tribes and Indigenous Peoples]).

In addition to emphasizing mitigation more prominently, GHG emissions and removals should be described in a consistent way across the report. Specifically, total emissions and net-zero emissions are often blurred together, as are removals and carbon sequestration (e.g., Figure 32.1 in Chapter 32 [Mitigation]). Furthermore, Figure 32.1. is confusing in this regard. The historical record is shown as gross emissions, with net-zero in 2050 shown as these emissions trending to zero emissions. Should the forest sink be included and continued, 2050 would be net negative, while “net-zero” would be reached around 2040. The statement that forests are a sink of 0.8 is not consistent with Chapter 7 (Forests), which reports the sink as 0.4. This confusion extends from what appears to be the absence of a standard inventory of emissions and removals across the entirety of the report. For example, NCA5 authors could select a consistent US emissions dataset and time frame based on the latest EPA national GHG inventory for 1990-2020 (EPA, 2022) with a standard benchmark year. Likewise, “key categories” should consistently refer to the chosen dataset. Such a dataset should be introduced to the reader (e.g., in the Front Matter or Chapter 2 [Climate Trends]), including appropriate caveats and limitations, and consistently cross-referenced throughout.

A key area of advancement since NCA4 is in negative emission technologies (e.g., carbon dioxide removal). Relevant to the discussions of adaptation and mitigation, these technologies should also be discussed as part of the broader portfolio of options to achieve net-zero GHG emissions, including relevant references (e.g., NASEM, 2019, 2021, 2022a).

Distinction Between Natural Variability and Climate Change

The draft NCA5 report frequently describes “change” but does not consistently distinguish between natural variability and climate change. This lack of clarity can be misleading for the reader by creating the misconception that some impacts that are the result of the combination of natural variability and climate change are instead solely due to climate change (e.g., Chapters 4 [Water], 6 [Land Cover and Land-Use Change], 9 [Coastal Effects], 28 [Southwest], 30 [Hawai‘i and US-Affiliated Pacific Islands]). Consistent with the mandate of the

GCRA, it is important for NCA5 authors to accurately identify the multiple drivers of change (including global change), in addition to climate change, and accurately attribute impacts. Clearly describing impacts due to natural variability, climate change, or a combination of the two is important not only for informing policy decisions, but also for building public understanding and trust in the report's messages. Climate change and natural variability should be clearly defined in the glossary and natural variability could be introduced in chapter introductions when the concept is important for understanding key messages.

Use of Scenarios

Where projections from multiple climate change scenarios are available, (e.g., RCPs 4.5 and 8.5), NCA5 should strive to report results from multiple scenarios. This is particularly important because the divergence between projected climate impacts based on different scenarios becomes more pronounced decades from now, especially after mid-century. Projections of sea-level rise from different climate models should also be included when such results are available. Specifically, regional chapters should utilize results from multiple emission scenarios (e.g., RCPs), sea-level rise scenarios, and climate models where such results are available. The Committee recognizes that many studies of climate change impacts only use the “Very High Scenario” (RCP 8.5). In such cases, only the projections from that scenario can be reported in NCA5, but the limited use of emissions or sea-level rise scenarios and climate models should be clearly reflected in confidence and likelihood levels and explained in the traceable accounts. Findings based on a single scenario and one or a few models should, all else being equal, receive lower confidence and likelihood than findings based on the application of multiple scenarios and models.

Data, models, and projections used to formulate likelihood statements should be standardized across the chapters. Appendix 3 describes the standard datasets provided to the NCA5 authors: downscaled model-based projections of temperature and precipitation and sea-level rise scenarios. However, the individual chapters deviate from these standard datasets in many cases, drawing from a variety of sources, including local assessments and past NCAs. Each chapter should, at minimum, provide statements based on the standard sources meant to be common across NCA5. If other sources provide different or more nuanced information then these sources can be utilized as well—but always as a supplement to the standard sources in Appendix 3, not in place of the standard sources.

Treatment of Focus On... Features

The Focus On... Features are topics chosen because of their cross-cutting importance but could be better integrated into the national and regional chapters. These features address interesting topics, and the Committee applauds their inclusion in the draft NCA5 report. However, they are only mentioned in passing in some relevant chapters (e.g., Focus on Western Wildfire in Chapter 7 [Forests], Focus on Risks to Supply Chains in Chapter 19 [Economics]). More importantly, the relevant chapters do not substantively integrate the Focus On... Features (e.g., Chapter 16 [Tribes and Indigenous Peoples] discusses COVID-19 and does not cite to the Focus on COVID-19 and Climate Change; Chapter 8 [Ecosystems, Ecosystem Services, and

Biodiversity] discusses wildfires but does not cite the Focus On Western Wildfires; Chapter 18 [Sector Interactions, Multiple Stressors, and Complex Systems] does not mention the Focus on Compound and Complex Events), and there are opportunities to use these features to reduce redundancies and point the reader to sections, and vice versa, with more detail. For example, Chapter 30 (Hawai‘i and US-Affiliated Pacific Islands) contains an entire box on Blue Carbon Ecosystems (Box 30.4). The chapter may more effectively reference the Focus on Blue Carbon and devote that box space to another relevant example.

Additionally, the Focus On... Features should reflect a structure similar to that of the national and regional chapters to effectively communicate the chosen topics. The bolded statements in each Focus On... Feature should be treated as key messages, be clearly and carefully written in concise, accurate sentences, and they should include confidence and likelihood statements. The traceable accounts should include a brief discussion of authorship, discuss the knowledge base, include references, and detail the rationale for confidence and likelihood statements, in line with the recommendations on traceable accounts above.

Use of Terminology

In general, careful attention to consistent terminology and precision of language is needed. The draft NCA5 report does not consistently use the metric or Imperial system between and within chapters. Chapter 1 (Overview) introduces the convention of Fahrenheit (Celsius) but does not use this convention consistently, which causes reader confusion. There are even inconsistencies within sentences, for example, in Chapter 2 (Climate Trends): “For every additional 1°C of global warming, the average US temperature is projected to increase by around 2.5°F.” Terminology for similar concepts is also used differently from chapter to chapter—for example, adaptation versus resilience, ocean economy versus marine economy, citizen versus resident, nature-based solutions versus natural climate solutions, carbon sequestration versus carbon removal, and land-use change versus land system change. The Committee acknowledges the challenges in coming to a consensus on acceptable definitions for terms used commonly and interchangeably across scientific disciplines. The Committee suggests defining terms where they are meant to have a distinct meaning in the report text and the glossary currently under development (e.g., explain the difference between carbon dioxide removal, carbon sequestration, and carbon capture use and sequestration/storage) and consistently use one of the terms (e.g., use adaptation instead of resilience) across the report where multiple terms convey the same meaning. Throughout the report, imprecise language is also frequently used—for example, “significantly,” “will,” and “driving.” This language makes assumptions about decision making, and in some cases, may suggest levels of scientific confidence that are not supported by the text, citations, and traceable accounts.

Recommendation 9: The draft NCA5 report should be revised to utilize and distinguish between the different use cases of sea-level rise projections and sea-level rise scenarios clearly and consistently.

Projected sea-level rise (SLR) is not treated consistently across national and regional chapters and is often inconsistent with confidence and likelihood levels defined in the Front Matter. Some regional chapters (e.g., Chapter 22 [Southeast]) utilize only discrete SLR scenarios

from the Sea-Level Rise Technical Report (Sweet et al., 2022), while others use projections from emissions scenarios in IPCC AR6 (e.g., Chapter 23 [US Caribbean]), and still others attempt to relate the two but do so incorrectly (e.g., Chapter 30 [Hawai‘i and US-Affiliated Pacific Islands], 28 [Southwest], 27 [Northwest]). An underlying cause of this inconsistency is the overlapping naming conventions between the SLR and emissions scenarios. For example, the Intermediate Scenario for SLR from Sweet et al. (2022) most closely corresponds to IPCC SSP5-8.5, which is the Very High Emissions Scenario, while the Intermediate Emissions Scenario corresponds to IPCC SSP2-4.5. Additional confusion arises from the discrete nature of the SLR scenarios, which contrasts with the ensemble-based IPCC projections used for all other climate indicators; misunderstanding these differences leads to inaccurate and poorly formed likelihood statements that cannot be appropriately derived from a discrete trajectory.

In general, NCA5 should utilize and distinguish between the different use cases of SLR projections versus SLR scenarios. Projections offer information about the range of possible SLR outcomes for a specific emissions scenario, while the scenarios provide a range of discrete decision-relevant timelines for the purpose of developing adaptation approaches. It is not good practice—nor is it necessary—to utilize only one type of SLR information to satisfy the dual needs of making likelihood statements and providing decision-relevant information. The Committee suggests two possible ways the draft NCA5 report can be improved in this regard. The first (and preferred) option is to standardize the use of the ensemble-based IPCC SLR projections to make likelihood statements—similar to how temperature and precipitation are handled—and to standardize the use of the Sweet et al. (2022) scenarios for use in discussing decision-relevant timelines. In this case, statements such as the one made on Page 9-20 Lines 7-8 would be formulated similar to those in IPCC AR6 Chapter 9—for example, “Considering only processes for which projections can be made with at least medium confidence, global mean sea-level will increase from 2020 to 2050 by Y [X to Z, likely range] meters for SSP1-1.9 and by B [A to C, likely range] meters for SSP5-8.5.” The second option is for NCA5 authors to narrowly focus on the Sweet et al. (2022) scenarios. In this case, clear guidance should be provided to chapter authors for how to formulate reasonable likelihood statements around these discrete timelines. One way to do this is to emphasize the use of Table 2.4 in Sweet et al. (2022), whereby a possible likelihood statement made using the scenarios in combination with NCA5 confidence/likelihood language could be, “The Intermediate SLR Scenario is *unlikely* to be exceeded for 3°C of global average surface warming by 2100 and is *about as likely as not* to be exceeded under Very High Emissions (SSP5-8.5) when including Low-Confidence Processes.” Regardless of which of the above options is chosen, Appendix 3 detailing the relationship between IPCC projections and the Sweet et al. (2022) SLR scenarios should be expanded as it does not adequately explain the relationship, nor does it adequately detail the difference between the framing and appropriate use cases of each source of information. Additional comments regarding the handling of SLR projections and scenarios are provided in Chapter 3 of this report.

Recommendation 10: Individual chapters across the draft NCA5 report—particularly national and regional chapters—should be better integrated and cross-referenced.

The structure of the draft NCA5 report begins with the physical science chapters (Chapters 2-3) that provide a foundation for the national chapters (Chapters 4-20), which support the regional (Chapters 21-30) and responses chapters (Chapters 31 and 32). The national chapters lay out foundational concepts and the regional chapters build on that information to explore

specific regional impacts. Better integration of sector and regional chapters would lead to a more coherent NCA5 that more clearly highlights the integrated complexities associated with climate change.

The national chapters appropriately cover issues at the scale of the United States. Some regional chapters raise topics that are not necessarily specific to that region but could be covered in appropriate national chapters. For example, Key Message 21.5 in Chapter 21 (Northeast) discusses whether finance for climate action plans is adequate. The text in this key message addresses both national and regional concerns, and the matter of adequacy of finance for mitigation and adaptation is certainly not limited to the Northeast region. Rather, this issue is of national importance, and it may be more appropriate to address the adequacy of finance in Chapters 31 (Adaptation) and 32 (Mitigation) and, if appropriate, have the regional chapters cover finance issues specific to the respective regions.

Cross-referencing chapters across the report demonstrates the inherent interconnections and complexities of climate change and its impacts. Overall, stronger cross-referencing between chapters would reduce redundancies and inconsistencies, create more space for authors to expand on certain topics, and strengthen connections between topics. For example, some regional chapters (e.g., Chapter 30 [Hawai‘i and US-Affiliated Pacific Islands]) appear siloed from the rest of the report and would benefit from comprehensive two-way cross-referencing with relevant national chapters. While all chapters may not have been available to authors at the time the draft NCA5 report was developed, there is an opportunity for authors to leverage information included in different chapters as the draft NCA5 report is revised.

Relatedly, regional authors should be mindful when citing studies that cover the nation rather than the region (e.g., Chapter 25 [Northern Great Plains] discussion of mental health) not to create an ecological fallacy when national analyses are downscaled to regions. Similarly, national chapters should be mindful when citing global studies (e.g., Figure 8.3). The NCA5 authors should identify global or national-level studies as such and use appropriate confidence levels when applying results to smaller geographic scales. Each chapter should discuss these limitations in the literature (as mentioned above) in their traceable accounts sections.

RECOMMENDATIONS ON EQUITY AND JUSTICE

Recommendation 11: For consistency, chapter introductions should include context on equity and justice as related to the chapter topic. To move beyond general statements, different dimensions of justice, including distributional, procedural, recognition, and intergenerational justice, should be addressed as appropriate throughout the chapter text. Related gaps in the literature should be identified in the text and traceable accounts.

The Committee commends the NCA5 authors for incorporating equity and justice into the report; however, there are opportunities to highlight related issues more intentionally and consistently across the chapters. Notions of “equity” and “justice,” along with their related dimensions, are critical when considering climate change impacts, mitigation, and adaptation. Acknowledgment emphasizes the rights and interests of populations that have traditionally been excluded due to gender, age, race/ethnicity, poverty, or other social factors, and helps to identify key questions and indicators that can be used to assess progress, issues of access, the distribution of costs and benefits, competing interests, as well as just transitions. Though these and related

terms will take on different meanings depending on the context, they can be applied in an appropriate manner across all chapters for consistency and cohesiveness.

Dimensions to consider include distributional, procedural, and recognition justice, as described in Chapter 1 (Overview) (page 1-40). As the dimensional overview on page 1-40 is critical for consistent integration across the report, the Committee suggests a citation for the definitions provided. In addition, the concept of intergenerational justice should be added. For consistency in term usage, NCA5 authors may reference the definitions in the Chapter 1 (Overview) (page 1-40) or develop and reference a more robust glossary with cited definitions (see Recommendation 12 below). To address different dimensions of justice, authors may highlight how resources, impacts, vulnerabilities, benefits, and burdens vary across populations or geographies; recognize who is typically involved in the decision-making processes; highlight historical norms regarding inclusion and representation; and identify who is typically left out of such processes. “Intergenerational” equity considers fairness or justice between present and future generations, including the burdens and costs that will be incurred by future generations as a result of action taken (or not taken) at present. Issues of access, including appropriate data and governance are also important to consider to support inclusiveness and equity. As climate change impacts, mitigation, and adaptation sometimes expose competing priorities, recognition of trade-offs, including equity and justice concerns, should be addressed when applicable.

Overall, there is substantial variation in how equity and justice issues are integrated across chapters. Some chapters, for example Chapter 9 (Coastal Effects), use the introduction to strongly frame the chapter in the context of equity and justice, while other chapters such as Chapters 6 (Land Cover and Land-Use Change), 7 (Forests), and 8 (Ecosystems, Ecosystem Services, and Biodiversity) make no mention of equity or justice in the introductions. Chapter 15 (Human Health) frames health in the context of equity and justice in the introduction and goes on to consistently integrate related issues throughout the chapter, including systemic connections, depth of reporting on disproportionate impacts (rather than a blanket statement), and related dimensions of equity. Chapter 18 (Sector Interactions, Multiple Stressors, and Complex Systems) strongly illustrates the systemic interconnections relating climate change to equity and justice, and uniquely—but importantly—integrates governance and data justice issues. Other chapters would benefit from following these examples. The Committee recommends including equity and justice framing in chapter introductions and prioritizing the integration of related issues throughout the chapters where possible, rather than stand-alone sections addressing the topic. Doing so would highlight systemic interconnections and help avoid the appearance of addressing the topic as an afterthought. Additional considerations for addressing equity and justice throughout NCA5 are outlined in Box 2-4.

Recommendation 12: A glossary of terms related to equity and justice should be adopted and/or developed to ensure consistent use of terminology across NCA5. Associated references should be provided.

To ensure consistency throughout the report, the Committee recommends the development or adoption of a glossary of terms related to equity and justice. Care should be taken to avoid terminology that is harmful to impacted communities, particularly the use of deficit language. For example, many chapters use the phrase “marginalized communities,” but referring to people as “marginalized” can perpetuate perceptions of inadequacy and lack of autonomy within the communities being discussed. Generally, it is best to be as specific as

BOX 2-4 Equity and Justice Considerations

The following aspects of equity and justice should be considered across all contexts and chapters:

- Who is vulnerable in this context, and why? Be as specific as possible (i.e., historically overburdened communities, geographically vulnerable, occupationally vulnerable, age-related vulnerability, medical vulnerability) and make connections with systemic factors that may lead to, contribute to, or perpetuate vulnerability;
- Intersectionality and its relationship with climate vulnerability, mitigation, and adaptation (Amorim-Maia et al., 2022);
- Questions of “for whom,” “by whom,” “where,” and “how” (which address just transitions and dimensions of equity including distributional, recognitional, procedural, and intergenerational);
- The role of environmental data justice/availability and accessibility to relevant data and information;
- The role of governance, particularly how the integration of local context and perspectives helps to address the different dimensions of equity;
- Knowledge sources outside of peer-reviewed literature, including grey literature, white papers, storytelling, and Indigenous knowledges;
- Name inequity/injustice as such;
- Highlight concerns that have been raised by traditionally underrepresented communities;
- Avoid deficit framing language, emphasize leadership and innovation;
- Recognize social and structural components when considering the compounding/cascading/complex impacts and risks;
- Identify trade-offs as they relate to equity and justice; and
- Present mitigation/adaptation solutions, case studies, and/or stories from diverse geographies, or populations that integrate equity and justice issues.

possible when describing equity-and justice-related issues—including populations—rather than relying on jargon and terms. The Committee recommends following a similar process as was used in the New York State Climate Impact Assessment³ process, in which a glossary of terms related to equity and justice was developed from respected information sources. In the draft NCA5 report, there is inconsistent use of terminology around climate and gentrification (e.g., eco-gentrification, green gentrification, environmental gentrification) and terminology on race and socioeconomic status (e.g., minority, racialized minority, BIPOC, low income, low wealth). For example, Chapter 15 (Human Health) uses both “low-income” and “low-wealth,” while most of the other chapters use “low-income.” These two terms are distinct and should be used appropriately based on the intended meaning. Agreement on one respected reference for each term, such as “low-income” and “low-wealth,” would help to ensure consistent use of terminology across the report.

Recommendation 13: To provide equitable access to climate-related information across US communities, national chapters should include all US islands and territories in their figures and assessments whenever possible.

³ See <https://nysclimateimpacts.org>.

Access to climate observations, projections, and assessments is not equitable across US territories, particularly for US-affiliated islands in the Pacific and Caribbean, which is noted in the respective regional chapters. NCA5 provides an opportunity to increase equity in this area, and every effort should be made to do so. Many figures in national chapters do not include the US Caribbean, and while many figures do include Hawai‘i, virtually no figures include the other US-Affiliated Pacific Islands despite the availability of information to do so. Whenever satellite data or global model output is used to generate national figures (e.g., Figures 2.4, 2.5, 3.7, 4.3), NCA5 should include a complete map of all island territories. If no data are available for these regions, the figure caption should state this to be the case (e.g., Figure 2.10). The Committee recognizes that including all island territories is not always optimal when attempting to produce legible figures for the contiguous United States due to the geographic extent of the US-Affiliated Pacific Islands. In such cases, the Committee recommends that separate figures be created for regions that are not included, that these figures be aggregated in an appendix, and that figure captions in national chapters point to this appendix for maps of regions not shown. Finally, the national chapters should strive to be more inclusive of island territories in textual statements and assessments of climate-related impacts and risks.

AREAS TO ADD EMPHASIS

Recommendation 14: Relatively more emphasis should be placed on the topics of: mitigation, adaptation successes and shortcomings, projected impacts of climate change, attribution of extreme events, and rural analysis.

In reviewing the draft NCA5 report as a whole, the Committee identified a number of topical areas where relatively more emphasis could be placed. In this section, the Committee outlines topics that should receive more complete attention across the report and identifies specific examples or inconsistencies across the report.

Mitigation

The treatment of GHG mitigation is uneven across the draft NCA5 report and should receive more attention in many of the chapters, consistent with its treatment in Chapter 1 (Overview). On the one hand, Chapter 32 of the draft NCA5 report is devoted to mitigation. In contrast, national chapters do not consistently emphasize mitigation or draw connections to Chapter 32 (Mitigation). Most notably, chapters on sectors that have significant GHG emissions or removals treat mitigation inconsistently. For example, Chapters 12 (Built Environment, Urban Systems, and Cities) and 13 (Transportation) have key messages on mitigation (i.e., Key Message 12.3, Key Message 13.1). On the other hand, Chapters 7 (Forests) and 11 (Agriculture, Food Systems, and Rural Communities) address GHG emissions with a focus on removals in text boxes, and Chapter 5 (Energy Supply, Delivery, and Demand) addresses GHG mitigation together with adaptation but does not include emissions or mitigation in any of the key messages. Some chapters discuss adaptation and mitigation as a grouped topic (e.g., Chapter 16 [Tribes and Indigenous Peoples], Chapter 15 [Human Health]), but then only examples of adaptation are provided with no specific discussion on mitigation. The inconsistent attention to mitigation

extends to the regional chapters. While Chapter 21 (Northeast) summarizes state GHG mitigation plans in a box and Chapters 26 (Southern Great Plains) and 28 (Southwest) summarize mitigation actions in the regions in figures, the other regional chapters say very little or nothing, or may discuss emissions reductions but do not refer to the actions as “mitigation” (e.g., Chapter 25 [Northern Great Plains]). Given the importance of mitigation in the consideration of climate change impacts in the future and the substantial knowledge base on mitigation, a greater emphasis on mitigation in the United States is appropriate.

Adaptation Successes and Shortcomings

Significant adaptation efforts are happening across the United States at all different scales. Summarizing the breadth of adaptation efforts is difficult because the United States lacks transparent and credible mechanisms to aggregate and assess the combined effectiveness of these measures regionally and nationally. The draft NCA5 report provides a competing dual analysis of adaptation. Many chapters describe specific adaptations, such as Chapter 21 (Northeast), that lists state and tribal adaptation plans. While recent work on adaptation is impressive, the recitation of adaptations does not assess whether and to what extent these measures will be successful in reducing risks from climate change. In contrast, Chapter 31 (Adaptation) finds that without a more dedicated effort toward transformation, the current trajectory of adaptations will be inadequate to fully mitigate the increasing risks from climate change and examines the need for transformative adaptation. Both views provide important insights—adaptations are being made but appear inadequate to fully adapt to how the climate may change. Chapter 31 (Adaptation) should better integrate these two points, and the synthesis of these two approaches to assessing adaptation should be carefully reflected in Chapter 1 (Overview). It would be appropriate for national and regional chapters to coordinate their discussions of adaptation to be consistent with the framework outlined in Chapter 31 (Adaptation). It may also be appropriate for NCA5 authors to acknowledge that adaptation actions related to infrastructure, human health, local economies, ecosystems, and emergency management are often about changing an element of a larger project that is already scheduled to occur, making projects challenging to assess as standalone adaptation actions.

Projected Impacts of Climate Change

The impacts of climate change are increasing, resulting in greater impacts on health, the built environment, and natural systems. However, the focus of many key messages across the draft NCA5 report is on recent observed changes and impacts. As noted above, a key requirement of the GCRA is to report on projected climate change impacts, specifically 25 to 100 years into the future, and relatively more emphasis on projected impacts is needed. For example, some sector chapters, such as Chapter 12 (Built Environment) and Chapter 13 (Transportation) devote little attention to projected climate change impacts. Many regional chapters focus only on recent impacts and would benefit from discussing projections and key uncertainties (e.g., Chapters 27 [Northwest], 29 [Alaska]). Furthermore, there is a tendency in some key messages (e.g., Key Message 4.1) to conflate or switch between current and projected changes in a confusing way. Care should be given not to intermix statements about observed and projected

changes in key messages. Recommendation 8 above details the suggested use of scenarios when projections are included.

Attribution of Extreme Events

The Committee commends the discussion in the draft NCA5 report on recent observed extreme events that identify how vulnerable society and nature are to climate change. Attribution of such events is an emerging field of research (e.g., NASEM, 2016). In many cases in the draft NCA5 report, extreme climate or weather are discussed (e.g., Chapters 4 [Water], 11 [Agriculture, Food Systems, and Rural Communities], 12 [Built Environment, Urban Systems, and Cities], 28 [Southwest]) but there is little or no discussion disentangling natural variability from climate change as causes of extreme events, as discussed above. For example, Chapter 28 (Southwest) discusses the current mega-drought affecting the entire region and cites Williams et al. (2022) but does not mention the causes of the drought or that the reference concludes that while climate change is making the drought more severe and long-lasting, natural variability has a relatively greater contribution to the severity of the drought than does climate change. As another example, the text in Chapter 1 (Overview) and Figure 1.4 are misleading because they imply the increase in the number of billion-dollar disasters is solely due to more intense weather and climate events. However, societal exposure to such events caused by population and property increases in hazardous areas also plays a significant role (see Figure 1.4 and explanatory text; Figure 2.6 and accompanying text; and Appendix 4, Figure A4.5). Chapters should be carefully written to emphasize that many extreme events have a higher likelihood of occurring due to climate change, rather than directly attributing extreme events to climate change, unless there is evidence to support the statement. Without precise attribution of extreme events, readers could be left with the impression that these events are entirely the result of climate change. There is an opportunity to expand the discussion of attribution of extreme events in the main text of Chapter 3 (Earth System Processes) to describe the concept in a more accessible way, the use of attribution studies and their limitations, and progress in the knowledge base since NCA4.

Rural Analysis

Rural communities are covered in Chapter 11 (Agriculture, Food Systems, and Rural Communities) and urban communities are covered in Chapter 12 (Built Environment, Urban Systems, and Cities). Impacts on urban communities are also addressed in other chapters of the draft NCA5 report, but the unique challenges and opportunities for rural communities are not adequately addressed. A more balanced discussion of rural communities would support the framework recommended for equity and justice, provided above. For example, Chapter 13 (Transportation) focuses on transportation networks in cities and omits discussions of rural mobility. Chapter 14 (Air Quality) covers environmental justice and air pollution risks in urban areas, with little attention to such risks in rural areas. Chapter 15 (Human Health) makes passing mention of rural farmers but does not discuss issues specific to rural communities (e.g., access to health care). Even though Chapter 12 (Built Environment, Urban Systems, and Cities) is focused on the built environment in urban areas, the built environment in rural areas is not covered in the

draft NCA5 report. The regional chapters generally do a better job of commenting on rural areas, though there are opportunities, for example, in Chapter 28 (Southwest), to place more emphasis on rural areas.

3

Chapter Comments

This chapter provides comprehensive reviews of each draft Fifth National Climate Assessment (NCA5) report chapter followed by the five Focus On... Features. Chapter comments respond to the questions outlined in the Committee's Statement of Task (see Chapter 1 of this report). For each chapter, the Committee provides comments following a consistent structure: summary of the Committee's comments; comments on the chapter introduction; comments on key messages, supporting information, and traceable accounts; comments on graphics and boxes; comments on equity and justice; comments on data and analyses; comments on literature cited; and other recommended changes. Reviews of the draft NCA5 report chapters with different structures (i.e., Front Matter, Chapter 1 [Overview], Appendixes) deviate from this general structure. Appendix A of this report provides detailed line-by-line comments for each draft NCA5 report chapter, as appropriate, and the References chapter includes a complete list of references for all suggested additions to the literature cited in the draft NCA5 report.

CHAPTER 0: FRONT MATTER

The Front Matter is well written and provides an accessible guide to the organization of the draft NCA5 report and guidance to readers on how to read it. The draft NCA5 report has a single Overview chapter (Chapter 1) focused on the report's findings, thus, the Front Matter could better introduce concepts and metrics that are relied upon throughout NCA5. The Committee suggests expanding the current discussion to elaborate on elements critical to understanding NCA5. For example, as discussed in detail in Chapter 2 of this report, the discussion of confidence and likelihood could be expanded on for general audiences.

In addition, the Front Matter states that "NCA5 authors were advised to assess the full range of scenarios available" (page 0-11, line 16), but some projections in the subsequent chapters report on just one scenario. There is some inconsistency throughout the report when projections are presented, and additional information could be provided in the Front Matter for clarification. For example: Were authors given any direction on which scenario to use when presenting future climate change impacts? Did authors consider consistently presenting more than one scenario (i.e., Low and High)? The Committee suggests including an explanation on the use of scenarios throughout the report. Consistent with the recommendation in Chapter 2 of this report to place relatively more emphasis on mitigation, it may also be useful as part of the introduction of scenarios in the Front Matter to include indicators of current policy scenarios to help audiences make the connection between often abstract emission scenarios and current policy.

The Front Matter of the draft NCA5 report does not currently comment on its intended audiences. Overall, the key messages and main text are appropriate for the intended audiences; however, there are instances in which the text is too technical or uses jargon, as detailed in the individual chapter reviews. The Front Matter may benefit from an explanation of the NCA5 authors' target audiences, as well as the intended audiences and use of the more technical traceable accounts sections.

The Committee suggests the Front Matter include a definition of the term “risk,” which is widely used throughout the draft NCA5 report but is never clearly defined. For example, the Front Matter could adopt a definition that is closely aligned with the Intergovernmental Panel on Climate Change (IPCC) definition of risk as the confluence of hazard, exposure, and vulnerability (IPCC, 2021b), if that is consistent with its use throughout NCA5.

Chapter 2 of this report notes that chapters throughout the draft NCA5 report use different structures to meet their topical needs. While these differences are appropriate, the Committee suggests the Front Matter note where different structures are used, and if possible, explain the process that led to their development.

Additionally, the map of NCA5 regions in Figure 1 could be improved. Authors should consider using boxes or lines to separate the different geographic domains being represented. In addition, because it is the first map readers will see when they start the report from the beginning, it would be useful to design the map in such a way to show oceans and connected countries.

Table 3 would be more useful if it presented projected carbon dioxide (CO₂) concentrations and levels of increases in global mean temperature at a particular point in time. To be consistent with the Global Change Research Act (GCRA), the Committee suggests presenting projections 25 to 100 years into the future.

Box 1 provides useful information on projected levels of warming and how to interpret them.

CHAPTER 1: OVERVIEW

Summary

Chapter 1 (Overview) is well organized and presents a set of findings that overall reflect the key themes from the underlying chapters in the draft NCA5 report. For the most part, this chapter is clear and written at a technical level appropriate for broad audiences. The Committee has the following main suggestions for improvement, and specific line-by-line comments are included in Appendix A:

1. Chapter 1 (Overview) should better cover the breadth of key messages and related information in the draft NCA5 report to accurately present a comprehensive synthesis of the report related to observed and projected climate change impacts, mitigation, and adaptation. While quite broad in its summary of the draft NCA5 report, this chapter does not discuss some important topics that are covered in the report such as the role of greenhouse gas (GHG) sequestration; low-carbon power sources for mitigation; the limited and, in many cases, transient climate change benefits in some sectors and regions; and geographic coverage of the entire United States, including territories.
2. In some instances, Chapter 1 (Overview) makes statements that could be perceived as policy prescriptive, including preferences for particular policy outcomes such as levels of mitigation or expressing a desire for certain forms of transformative mitigation or adaptation. It is appropriate for NCA5 to provide information that is policy relevant but not to express policy preferences or prescriptions.

3. In a few cases, based on what is presented in the draft NCA5 report chapters, the Committee is concerned that the confidence findings are misrepresented in Chapter 1 (Overview). This discrepancy is most noticeable where projections are stated using “will,” but the underlying state of knowledge as expressed in traceable accounts does not justify such a high level of confidence.
4. In many cases, Chapter 1 (Overview) does not put impacts or extreme events in appropriate context, thus potentially creating the misleading impression that impacts are solely caused by climate change. This includes sectors and impacts that are affected by other global changes or societal changes and weather and climate events that may be affected by natural variability as well as climate change.
5. Chapter 1 (Overview) does not address whether adaptation has the potential to offset projected adverse impacts of climate change or whether there are limits to adaptation, particularly at higher levels of warming.

Chapter 1 (Overview) is a comprehensive assessment of the state of knowledge on climate change and addresses all the topics specified in the GCRA. However, Chapter 1 (Overview) does not specifically identify projected impacts of climate change 25 to 100 years in the future as required by the GCRA, reflecting the lack of projections particularly 100 years in the future throughout the draft NCA5 report, identified in Chapter 2 of this report. In some cases, projected impacts are provided for mid-century or for a given level of warming, but many are expressed without a time frame or specific increase in average global temperature.

Review Comments Related to the Statement of Task

Comments on Chapter Organization

The Committee commends the NCA5 authors for developing a single chapter to summarize and synthesize the report, rather than including both a Summary and an Overview as was done in the Fourth National Climate Assessment (NCA4). This change helps make the introductory information clearer and more concise in the draft NCA5 report. Chapter 1 (Overview) generally synthesizes key messages from the draft NCA5 report into broader cross-cutting messages well, and accurately summarizes new science on climate change and key findings on observed and projected impacts of climate change since NCA4. Overall, Chapter 1 (Overview) is well structured and appropriately written for broad audiences. Specifically, the Committee commends the emphasis on mitigation and adaptation efforts by noting in Section 1 both that progress is occurring to advance these efforts and that more is needed to meet stated emissions goals. However, while Chapter 1 (Overview) does discuss mitigation, often mitigation efforts are discussed in conjunction with adaptation measures. The Committee suggests that Chapter 1 (Overview) provide definitions and context to facilitate a greater understanding by broad audiences. For example, the text in Chapter 1 (Overview) should provide clear definitions for adaptation and mitigation that include answers to the following: what is mitigation; how does mitigation differ from adaptation; what time frames matter for mitigation efforts, and why. This context, which is presently omitted, will take up only a small amount of text, vastly increase accessibility to all audiences, and better set the stage for the rest of the chapters in NCA5. Additionally, since the draft NCA5 report utilizes an iterative risk management approach,

chapter authors may point out that mitigation is the primary tool to reduce likelihood broadly, while adaptation reduces consequence locally.

Comments on Consistency with Report Text

The Committee recognizes that it is challenging to decide which messages and supporting information are important to include in Chapter 1 (Overview) of such a comprehensive report. However, in some cases, the chapter is not consistent with the body of the report. For example, in the Chapter 1 (Overview) discussion on the specific needs to meet stated emissions goals in the coming years, there is a focus on renewable energy without any discussion of other options for reducing net GHG emissions or radiative forcing. However, several other chapters discuss the importance of options such as carbon capture and carbon sequestration (e.g., Chapter 8 [Ecosystems, Ecosystem Services, and Biodiversity], Chapter 11 [Agriculture, Food Systems, and Rural Communities], and Chapter 32 [Mitigation]), and energy conservation, nuclear power, or new technologies such as hydrogen fuels (e.g., Chapter 32 [Mitigation]).

Additionally, in summarizing sector and regional impacts, Chapter 1 (Overview) only mentions adverse impacts of climate change and does not mention the mix of impacts reported for some sectors and in some regions. This is most notable in Table 1.2 (see Appendix A for specific comments). Specifically, chapters such as Chapter 25 (Northern Great Plains) and 19 (Economics) describe a mix of impacts—often where there are some beneficial effects associated with trade-offs. For example, energy use and recreation are estimated to have a mix of impacts. Chapter 19 (Economics) shows in Figure 19.1 that expenses for electricity are projected to increase while expenses for fossil fuel use are projected to decrease. Additionally, the draft NCA5 report points out in many cases that cold weather recreation is expected to decrease due to warming temperatures and changing precipitation patterns, but it does not fully address how warm weather recreation could change. The Committee suggests that Chapter 1 (Overview) more accurately and transparently represent a mix of impacts associated with climate change as reported in some national and regional chapters, while highlighting that the knowledge base consistently finds that the net effect of climate change is projected to be negative, and increasingly negative with additional levels of warming.

Care is needed to ensure that Chapter 1 (Overview) accurately reflects confidence and likelihood statements in sector and regional key messages and their supporting traceable accounts. For example, Chapter 1 (Overview) appears to overstate levels of confidence and likelihood in its statements on agriculture and the relationship between incremental increases in temperature and damages compared to the levels of confidence and likelihood that are expressed in Chapters 11 (Agriculture, Food Systems, and Rural Communities) and 19 (Economics). To state an outcome “will” happen can be interpreted as having the same as finding the outcome is *virtually certain* with *high confidence*. Chapter 1 (Overview) states that climate change “will” make food less accessible and more expensive (Section 3.2, page 1-18, lines 14-15). Key Message 11.2 states that, based on projections, the outcome is *likely* with *medium confidence* because there are relatively few studies, in addition to other factors such as adaptation and baseline changes that can have an important effect on vulnerability. Thus, these qualifications provided in Chapter 11 (Agriculture, Food Systems, and Rural Communities) do not support attaching “will” to findings on climate change and food production.

Chapter 1 (Overview) also states, “Each additional increment of warming will cause more damage and greater economic losses than previous warming, while the risk of catastrophic

or unforeseen consequences also increases” (Section 1.1, page 1-4, lines 14-15). The Committee agrees that the evidence presented in the draft NCA5 report and the broader knowledge base supports the expectation that with increasing changes in warming, there will be increasing net damages. However, the Committee questions whether the use of the word “will” is appropriate for this finding. There are important uncertainties regarding climate change, impacts, adaptation, and baseline changes that justify less than complete certainty in this finding. The traceable account for Key Message 19.1, for example, points out many important uncertainties regarding the relationship between increased warming and damages. An indication of some uncertainty in this finding would be more consistent with the state of knowledge expressed in Chapter 19 (Economics) and could be addressed by substituting language from Chapter 19, “with every additional degree of warming, the United States overall is expected to see increasingly adverse consequences.” The second clause of the sentence is appropriate and should remain as written.

Comments on Top-Line Messages

Most of the top-line messages in Chapter 1 (Overview) are clearly stated and supported by subsequent chapters. However, Section 5 (“How We Move Forward”) has some findings that may be perceived as policy prescriptive. For example, statements that transformative adaptation reduces inequalities is not a statement of fact (Section 5.3, page 1-39, lines 1-24). While transformative adaptation can reduce inequalities, some transformative adaptations may not reduce or could even exacerbate inequalities if not carefully pursued through an equity lens, as noted in Chapter 31 (Adaptation). The Committee suggests carefully rewording statements like these that state values to be policy informative without being policy prescriptive.

Additionally, some of the subsection headers need clarification. For example, the headers for subsections 1.3 (“Adaptation is moving forward across the country”) and 1.4 (“Communities are taking action to strengthen resilience”) are similar and authors should clarify the distinction between the two and consider an alternative header for subsection 1.4 such as “Communities are acting on climate change.” The header for subsection 4.2 (“Rising emissions are driving rapid global warming”) is also ambiguous given that the rate that emissions rise depends on the timescale considered and should be rephrased. Furthermore, many headers in Section 3 (“The Risks We Are Facing”) are overly broad. For example, in Section 3.8 (“Regional economies and livelihoods”), while many livelihoods, cultures, heritages, and traditions are being adversely affected by climate change, the section title can be read to imply that all of the components of these categories are adversely affected. Some rephrasing could address this concern—for example, use “many livelihoods” or state “cultures, heritages, and traditions” are being affected.

Comments on Documentation from Other Chapters

In general, the individual chapters are appropriately addressed and referenced in Chapter 1 (Overview); however, there are several exceptions. For example, page 1-20, lines 31-33, states that sea-level rise (SLR), fire, and flooding are expected to displace millions of Americans, but it is not clear where the magnitude of displacement (i.e., millions of people) is stated in the chapters or in the underlying literature. Furthermore, Chapter 19 (Economics) discusses migration but states that specific impacts, such as levels of migration, are uncertain (page 19-12, lines 7-8). Appendix A identifies additional discrepancies between the draft NCA5 report

chapters and Chapter 1 (Overview) and makes suggestions for cross-referencing specific chapters.

Comments on Graphics and Boxes

While some figures in Chapter 1 (Overview) were not available for the Committee to review, the figures that are displayed were generally clear and informative.

The title of Figure 1.2 should indicate the time period of the data portrayed. The caption should address the geographic areas where warming has not appeared to have occurred or, if appropriate, point out where in the report this topic is addressed.

The text and Figure 1.4 are misleading because they imply the increase in number of billion-dollar disasters is solely due to more intense weather and climate events. Non-climate stressors also contribute to the increase in such disasters, such as population growth, particularly in areas most exposed to climate hazards, and property values, which have increased faster than the general rate of inflation. Figure 2.6 in Chapter 2 (Climate Trends) displays billion-dollar disasters in 2021 but does not address how the number of such disasters has changed over time. Thus, Figure 1.4 appears to be presenting information not found in the body of the draft NCA5 report. Additional comments are provided in Appendix A.

The titles and labeling of Figure 1.18 are confusing. The figure appears to display the relative cost effectiveness of emissions reduction options, not how much carbon will not be emitted. While the figure is still under development, as depicted, it is unclear based on the multiple titles and labels on the figure whether the figure is showing emissions reduction potential by abatement measure, savings per abatement measure, cost per million metric tons (MMT) of CO₂-equivalent offset by each abatement measure, incremental cost per MMT of CO₂-equivalent offset by each abatement measure, or some combination. The figure title and label of the x-axis should be rewritten to make it clear that the figure is displaying dollar per ton of net emission reduction. Additionally, the Committee suggests that the figure be modified to use more distinct color gradients (blues and yellows are tough to discern). Finally, in the caption, the term “marginal costs” should be explained, as well as the key take aways from the figure.

Table 1.1 provides good examples of adaptation, but the examples are limited. While it is challenging to portray comprehensive examples of promising adaptations, one option would be to include broader efforts such as federal and state adaptation measures along with local measures.

The structure of Table 1.2 is useful. However, the title of Table 1.2, “All Regions Are Experiencing a Mix of Adverse Impacts” is not clear on what a “mix of adverse impacts” means. In addition, the table does not reflect the mix impacts presented in some chapters of the draft NCA5 report. For example, entries for the Northeast, Midwest, and Northern Great Plains focus on adverse impacts; not all livelihoods will be harmed, and some could benefit.

Comments on Equity and Justice

Overall, equity and justice issues are appropriately addressed and well-integrated in Chapter 1 (Overview). The chapter authors provide important historical drivers of inequity and include present-day implications. Systemic interconnections are well addressed and provide strong framing across the chapter. The chapter authors do not focus on only race/ethnicity and economic status when addressing inequity and vulnerability, but also highlight other historically

overburdened communities as well as geographic vulnerabilities (i.e., rural areas) and occupational vulnerabilities (i.e., small fisheries).

However, the Committee suggests several minor improvements. Consistent with the recommendation in Chapter 2 of this report, Chapter 1 (Overview) should use more consistent terminology; for example, “under-resourced,” “overburdened,” and “frontline” seem to be used interchangeably in the chapter. Chapter 1 (Overview) should adopt consistent terminology that will be used throughout NCA5. Chapter authors may consider including the concept of intersectionality and its relationship to climate vulnerability. Some attention to data justice, or the availability and accessibility of relevant data to communities, may be warranted in some contexts; for example, it is a broad and unbacked assumption that “communities are now equipped with a stronger understanding of the risks they face” (page 1-4, lines 4-5) as accessibility to relevant climate data is highly variable. Finally, the Committee also suggests including “intergenerational justice” in the list of relevant forms of justice in subsection 5.5 (“Transformative change is an opportunity for a more just Nation”). Additional specific suggestions are identified in Appendix A.

Comments on Data and Analyses

This chapter presents some data from underlying chapters and in general, these are presented well. The Committee notes concerns above about figure titles and captions that could be clearer and should present appropriate caveats about the data being presented. The chapter should adopt a standard dataset framework (e.g., GHG emissions), consistent with the recommendation in Chapter 2 of this report, so that references to data are always consistent and correct.

Other Recommended Changes

In many cases, Chapter 1 (Overview) does not put impacts in the appropriate context, which could create the misleading impression that impacts, including some changes in extreme events, are entirely caused by climate change. For example, regarding impacts on ecosystems, Chapter 1 (Overview) should state that ecosystems are also being degraded by other global changes such as land-use, habitat fragmentation, pollution, and overfishing. The chapter should point out that some extreme events are partly the result of natural variability, as well as climate change.

In general, the chapter does not address whether adaptation has the potential to offset projected adverse impacts of climate change, nor does it examine limits to adaptation. While Chapter 31 (Adaptation) discusses limits to incremental adaptation and the need for transformative adaptation, evaluating both the possibilities and limitations of adaptation is essential to every sector for future planning, and should be addressed in the chapter. The Committee notes that this is a challenging topic to assess; however, some discussion is warranted either highlighting the knowledge gap or explaining why these topics were not addressed.

The implications of international impacts of a changing climate on the United States, including possible effects on national security and the opening of the Arctic to shipping and resource extraction, are not addressed in the chapter, except for migration.

Finally, the Committee questions the citation of global economic damages that is drawn from Chapter 17 (Climate Effects on US International Interests). Since the draft NCA5 report

focuses on impacts on the United States, the Committee suggests Chapter 1 (Overview) cite findings from Chapter 19 (Economics) on estimated impacts of climate change on US gross domestic product (GDP) (e.g., US GDP is projected to fall by 0.13% per degree Fahrenheit increase; page 19-12, lines 25-27).

CHAPTER 2: CLIMATE TRENDS

Summary

This chapter summarizes the observed climate trends in the United States and their causes and impacts, providing a foundation for the rest of NCA5. The chapter is written in a consistent, transparent, and credible way and does a great job of using accessible language and not assuming knowledge of scientific terms and jargon. While the chapter covers a wide range of topics, including temperature, rainfall, and sea-level, among others, the discussion and references regarding the role of natural climate variability and its regional differences are missing. The key messages are well stated and supported by the details provided. The chapter meets the requirements of Section 106 of the GCRA. This chapter and Chapter 3 (Earth System Processes) should be better coordinated, described below and in the Committee's review of Chapter 3 (Earth System Processes).

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction is generally well written. It not only provides a useful background for the subsequent three key messages, but also discusses connections to other chapters. The introduction could be improved by adding more discussion of the connection to Chapter 3 (Earth System Processes)—specifically, to explain the overlap between the two chapters and distinguish each chapter's focus. Highlighting these connections is especially important as these two chapters provide foundational information for the following national and regional chapters; thus, later chapters should be able to clearly reference pertinent physical science in each of these chapters. Because this chapter relies on IPCC reports, it would be useful to make clearer when references are being made to that source, and more attention could be given to what is new in this chapter compared to NCA4. Additionally, "climate trends" is an incredibly broad topic that cannot fully be covered within this chapter; therefore, it is important for the introduction to include a statement about the information that is not included in the chapter.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The key messages are generally well written, at the appropriate technical level. They reflect current understanding about observed and projected impacts to the United States, the challenges, opportunities, and success stories for addressing risk; and identification of emerging issues related to climate change. Assessments of confidence and likelihood are included, though chapter authors could consider always putting confidence/likelihood language in parentheses for

clarity. In the key message titles and subsection headers, authors should avoid using personal pronouns because they lack clarity and should also exercise caution when making declarative statements in headers that are not supported by the corresponding text.

One major issue missing from this chapter is a comprehensive discussion of the issue of ocean acidification, which is likely to have profound impacts on natural ecosystems, as well as ocean resources such as fisheries. There are currently a few mentions of this topic, but the discussion should be expanded.

Comments on Specific Key Message Language

Key Message 2.1. Climate Is Changing, and Scientists Understand Why

It is *virtually certain* that human activities have increased atmospheric levels of carbon dioxide and other greenhouse gases (*very high confidence*). Global average temperature has risen in response, with even more warming experienced in the continental United States and Alaska (*virtually certain, very high confidence*). Long-term changes have been observed in many other aspects of the climate system (*very high confidence*). The Earth system is complex and interconnected, which means changes in faraway regions also affect the United States (*high confidence*).

Key Message 2.1 is well written and sets the foundation for the other two key messages by emphasizing the fact that the climate has already been changing. This key message also provides a single location where almost all of the climate changes discussed and expanded upon elsewhere are introduced for use by the other chapters.

Key Message 2.2. The Risk of Extreme Events Is Increasing

Observations show an increase in the severity, extent, and/or frequency of multiple types of extreme events (*very high confidence*). Heatwaves have become more common since the 1980s (*very high confidence*). Drought risk has been increasing in the Southwest over the past century (*very high confidence*) and decreasing elsewhere (*medium confidence*). Rainfall has become more extreme in recent decades, especially east of the Rockies (*very high confidence*). Hurricanes are intensifying more rapidly (*high confidence*) and causing heavier rainfall and higher storm surges (*high confidence*). More frequent and larger wildfires have been burning in the West in the past few decades due to a combination of climate factors and policy (*high confidence*).

Suggested title: “Extreme Events Are Becoming More Frequent and Severe.”

Key Message 2.2 is another generally well written key message. However, while the title of this key message includes the word “risk,” the key message is exclusively about hazard. The Committee suggests rewriting the key message title to more accurately reflect the discussion on hazards.

Key Message 2.3. The Future Is in Our Hands

The more the planet warms, the greater the impacts—and the greater the risk of unforeseen consequences (*very high confidence*). Scientists understand much about the Earth system, but there are still uncertainties about how the planet will react to rapid warming. Risks increase with warming, and warming increases with emissions (*very high*

confidence). Reducing emissions would limit future warming (*very high confidence*) and the associated increases in risks (*medium confidence*). While worst-case scenarios cannot be ruled out, the future is largely in our hands.

This key message title is not scientific and seems to ignore equity and justice concerns on the very question of who has the power in the United States to shape climate and energy policy. The title does not describe the information included in the supporting text well—the audiences would expect the text supporting this key message to be about policy actions, but a more appropriate title would have to do with climate impacts. Additionally, this key message could be more direct if it began with the third sentence and the first two sentences were removed. Furthermore, the Committee suggests that authors avoid using first person language in the title and key message.

Comments on Text Supporting the Key Messages

The text supporting the key messages is generally well written and contains sufficient details that provide further context. Detailed comments on the text are provided in Appendix A. Some of the statements, including section headers, however, should be clarified. For example, the section header, “The Nation Has No Choice But to Adapt to a Changing Climate” is unclear because “the Nation” can refer to both the people of the United States and the government, and the supporting text in the section only makes broad statements about “the Nation.” The Committee suggests rephrasing the section header to be more precise, for example, “Adaptation can address climate change impacts.”

When discussing regional differences in climate trends across the United States, the impact of natural climate variability is mostly ignored with a few exceptions. The role of natural climate variability and its interaction with human-induced climate trends in temperature, precipitation, and sea-level is documented widely in the scientific literature and is essential for proper interpretation of observations. It is important to point out that locations where natural climate variability is currently suppressing the impact of climate change can expect to experience rapid increase in the suppressed variable if/when the natural variability changes phase (e.g., sea-level rise [SLR] along the west coast of North America). It is also important to point out that the influence of natural climate variability becomes particularly strong when the climate trend is computed based on short periods of time or small geographic areas.

The title of the subsection “Sea Level Rise Will Continue to Accelerate” implies too much certainty. For example, global SLR under Shared Socioeconomic Pathway (SSP) 1-1.9 does not continue to accelerate. Even though this is the Very Low Emissions scenario, and even though a case could be made that the probability of a very low emissions future is low, the title of this key message is “The future is in our hands.” If emissions were drastically curbed emissions starting now, SLR may not continue to accelerate. The Committee suggests changing the title to “Sea Level Rise Is Expected to Continue Accelerating.” Within this subsection, it should be noted under what conditions (i.e., emissions scenarios excluding Very Low) SLR is expected to accelerate. However, even within a higher emissions scenario, there may be individual ensemble members for which SLR does not accelerate, and herein lies an important distinction between projections and scenarios. Likelihood statements (including the word “expected”) can be made using projections based on emissions scenarios. Likelihood statements should not be made based on SLR scenarios. In general, a distinction should be made between

projections and scenarios here and throughout NCA5. Also in this section, the word “likely” is used often. Is this word used in the context of NCA5 confidence/likelihood language? If not, a different word should be used. If so, the word should be italicized, and the justification for these likelihood statements should be based on projections (not scenarios) and added to the traceable accounts.

Comments on Traceable Accounts

This chapter could better identify and provide sufficient context for embedded content and explain how the chapter content reflects current scientific understanding by following the recommended framework for traceable accounts sections in Chapter 2 of this report. In addition to the introduction, relevant connections to Chapter 3 may also be appropriate. The “Major Uncertainties and Research Gaps” section listed under Key Message 2.1 seems arbitrary. Chapter authors should remove subtitles and add discussion of other sources of uncertainties and gaps. The Committee suggests referencing the recommendation in Chapter 2 of this report for more guidance on enhancing traceable accounts.

Comments on Graphics and Boxes

Graphics in this chapter are generally effective and appropriate, though improvements would increase accessibility for the intended audiences. Several figures (e.g., Figures 2.2, 2.7) are highly technical and could be better presented for general audiences. Figure captions should be expanded to discuss what the figures mean rather than just what exactly they show. Many figures in this chapter could be made larger or broken out into separate figures to enhance readability.

Figure 2.4 is informative, and the first sentence of the caption is a good example of explaining what the figure means, although even “obvious” points like “With differences from region to region and season to season” might be useful additions for general audiences. In general, figure captions should be as much about what the reader should learn from the figure as about its technical sources (e.g., the caption for Figure 2.4 is one line of “what it shows” and six lines about where it comes from). In addition, showing how temperature and precipitation changes (in degrees and by percent from the average) compared to the natural variabilities (e.g., masking by T test) would be helpful.

The US-Affiliated Pacific Islands (USAPI) and in most cases the US Virgin Islands (USVI) are missing from figures (Figures 2.2, 2.4, 2.5, 2.7, 2.8, 2.9, 2.12) and text. If NCA5 is to be equitable, it should support and provide relevant climate information equally across all United States lands and territories. If the USAPI and USVI do not fit nicely into the current figure formats (it is understandable if they do not), then additional figures should be made and provided in an appendix of figures specifically for USAPI and USVI locations, which can be referenced in the text to point interested readers and decision makers to the relevant information for these locations. This should be possible for any maps based on satellite data or global models (e.g., Coupled Model Intercomparison Project Phase 6 [CMIP6]).

Comments on Equity and Justice

The introduction merely mentions that “Black Americans die from heat-related diseases at a rate twice that of the general population (EPA 2022b).” The Committee suggests highlighting how climate trends relate to equity and justice in the introduction and integrating associated dimensions (distribution of benefits and burdens, recognitional, procedural, intergenerational justice) in the chapter body as appropriate. Adding references to other chapters that discuss related equity and justice issues (e.g., disproportionate impacts from climate change) would help build consistency with the rest of the report.

Within the text, more effort should be made to assess the literature and make statements regarding observed and projected trends for the USAPI and US Caribbean. Not only would this support Chapters 23 (US Caribbean) and 30 (Hawai‘i and US-Affiliated Pacific Islands), but these regions are the most lacking in climate information. This report is an important opportunity to support climate information and decision making in these vulnerable territories.

Comments on Data and Analyses

Data and analysis adopted from other sources and presented in this chapter are appropriate. However, this chapter frequently switches between the Imperial and metric systems (e.g., Fahrenheit and Celsius, feet and meters) in both the text and figures. Consistent units should be used both across this chapter and in accordance with unit conventions adopted in other chapters of the report (i.e., Chapter 1 [Overview]).

Comments on Literature Cited

Overall, appropriate literature is cited. Some suggestions are listed below, and others can be found in Appendix A.

It is unclear how the reported amounts of averaged SLR along the continental United States (CONUS) coasts were obtained on page 2-24 lines 32-34. Assuming the source is Sweet et al. (2022), the values reported here are not provided explicitly in that reference. One could look at Table 2.4 in Sweet et al. (2022) and see that 2°C warming most closely corresponds to the Intermediate Low Scenario (50%), while the Low and Intermediate scenarios correspond to the tails of the probability distribution (98% and 2%, respectively). Chapter authors could then look at Table 2.3 in Sweet et al. (2022) and find a Low to Intermediate range for CONUS average sea-level of 0.6-1.2 m (2-4 ft) in 2100 and 0.8-2.2 m (2.5-7 ft) in 2150. Both ranges differ from the ranges given in the draft NCA5 report. For page 2-24, lines 36-37, the Committee assumes this statement is based on the Intermediate scenario, but the Intermediate scenario is just as likely from a probability standpoint as the Low scenario for 2°C warming. So, if it is very unlikely that CONUS SLR will exceed 4 feet in 2100 for 2°C warming, then it is also very unlikely it will be as low as 2 feet, which is reported as the lower bound of what appears to be a likely range two sentences prior. This section needs work to be internally consistent with the draft NCA5 report likelihood ranges, as well as Sweet et al. (2022) on which it is based.

Other Recommended Changes

On page 2-14, lines 12-13 state, “The number and cost of weather-related disasters has increased dramatically over the past four decades, in part due to the increasing frequency and severity of extreme events.” The statement is technically correct because increases in extreme events are “in part” the cause of increases in billion-dollar disasters. However, this section should also acknowledge the important trends in baseline socioeconomic conditions that have resulted in a significant increase in exposure to such events. Three contributing factors are (1) increased population—United States population rose from 226 million in 1980 to 331 million in 2020, a 46 percent increase¹; (2) the Consumer Price Index has been lower than increases in property values^{2,3}; and (3) there is evidence that there is more development in hazardous areas than in relatively safer areas and that development in hazardous areas is increasing more than in less hazardous areas in the United States (e.g., Iglesias et al., 2021). It is important that the draft NCA5 report put such data as change in billion-dollar disasters in appropriate context.

CHAPTER 3: EARTH SYSTEM PROCESSES**Summary**

Overall, Chapter 3 (Earth System Processes) adequately identifies and supports the key findings, and the authors should be commended for putting together a nice chapter on a short deadline. The chapter largely meets the requirements of Section 106 of the GCRA. Most of this chapter is a summary of the relevant IPCC chapters. This is an appropriate way to bridge between the IPCC, which represents 4 years of synthesis of the science from a 1,000-page document of global scope, and this document focused on the United States, especially in terms of impacts and mitigation. The language and confidence limits are in general well done. Below, the Committee focuses on issues that can be improved.

The first issue is the number of key messages: 12 for this chapter, while most other chapters have three to five. Consistency between chapters would improve the readability and usability of the document. The four “methods” key messages, and especially the descriptions of the scenarios and ensembles, could be better presented as subsections in the text supporting the key messages, appendixes, or perhaps boxes. Some of the scenario descriptions are in the Front Matter and in Appendix 3, which may be more appropriate instead of in Chapter 3 (Earth System Processes). Regardless, these scenario sections should be consistent and refer to each other. Some other key messages could be combined—for example, Key Messages 3.1 and 3.5 could be combined; Key Message 3.6 and 3.12 could be combined; and Key Messages 3.3 and 3.8 through 3.11 could be combined.

Second, there is substantial overlap in key message titles between this chapter and Chapter 2 (Climate Trends). The Committee notes that the separation of the physical science chapter into two is new in NCA5, so authors are working this out for the first time. Chapters 2 (Climate Trends) and 3 (Earth System Processes) should complement each other and be carefully balanced to have enough similar—but not entirely duplicated—information, designing the

¹ See <https://www.census.gov/data/tables/time-series/dec/popchange-data-text.html>.

² See <https://www.whitehouse.gov/cea/written-materials/2021/09/09/housing-prices-and-inflation>.

³ See <https://anytimeestimate.com/research/housing-prices-vs-inflation>.

separation of information to serve different purposes or audiences. It may help if the authors of these two chapters coordinate with each other to work out the best way to minimize the overlap while maintaining the completeness of discussion. It would help the reader if there was an explanation in the chapter introductions about what material is covered in each chapter, as well as some information in the Front Matter. In addition, Chapter 2 (Climate Trends) and Chapter 3 (Earth System Processes) should cross-reference each other frequently.

Third, one important role that this chapter could play is to provide technical background information (in service of the other chapters) at a level that general audiences could understand. Presenting a few introductory topics in clear language—for example, explaining how and why the odds of some extreme events are increasing, and how they are attributed to climate change—could make important topics accessible to general audiences, and would be particularly useful for many of the other chapters to reference. Attribution of extreme events is being reported in the newspapers all the time; explaining what readers should look for in such reporting and why attribution is important would provide a service to all NCA5 audiences.

Lastly, key message titles should be rewritten to be messages themselves. For example, “Key Message 3.2. Climate Sensitivity and Climate Feedback” could be replaced with “Climate sensitivity and climate feedbacks will determine future changes and impacts” or some other title that provides meaningful information.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

Overall, the introduction is nicely written but reads as more of a summary. Chapter 3 is one of the most technical chapters in the draft NCA5 report, so the authors should emphasize in an accessible way why the topics are important for the audiences. In the spirit of focusing on knowledge gains since NCA4, the introduction should explain that this chapter is a new addition since previous NCAs. An additional sentence or two on the following should also be incorporated: (1) what is described in this chapter versus Chapter 2 and (2) frame the chapter topics in the context of equity and justice.

Comments on Key Messages, Supporting Information, and Traceable Accounts

In general, the key messages are well written and present appropriate information. The number of key messages should be reduced to be consistent with other chapters, as suggested above. The key messages are short, so combining them should not be too difficult. There is also overlap with Chapter 2 on some topics, for example, climate drivers (e.g., GHGs, aerosols), extreme events (e.g., temperature and precipitation), the cryosphere, and SLR as well as the role of natural variability. Additionally, focusing on fewer topics (e.g., attribution of extreme events) and explaining them in a less technical way would be valuable. Finally, the key message titles themselves should contain information, not just be headers. There are confidence statements but no likelihood statements; these should consistently be provided across all chapters, consistent with recommendations in Chapter 2 of this report.

Comments on Key Messages and Supporting Information

Key Message 3.1. Drivers of Climate Change

Human activities—primarily emissions of greenhouse gases—have caused nearly all global warming observed over the industrial era (*very high confidence*). Changes in natural climate drivers had globally small and regionally variable long-term effects over that period (*high confidence*).

This is a well-written section, although there is some duplication with Chapter 2 that could be removed by adding cross-references.

Key Message 3.2. Climate Sensitivity and Climate Feedback

Recent improvements in the understanding of how climate feedbacks vary across timescales have narrowed the estimated *likely* range of warming expected from a doubling of atmospheric carbon dioxide by 50% to between 4.5°F and 7.2°F (*high confidence*).

This is a well written section; however, because it is a technical subject and consistent with suggestions above to combine key messages, this key message could be combined with others.

Key Message 3.3. Changes at Regional Scales

Changes in regional climate can differ substantially from changes in global-scale averages, and natural variability in the climate system limits the precision of regional-scale projections. Thus, it is important to account for regional differences as well as natural variability when providing climate change information. (*Very High Confidence*)

Key Message 3.3 is a solid key message, but all the references are to model studies. Referencing some observational papers or Chapter 2 (Climate Trends) would improve the flow, authority, and cohesiveness of this key message.

Key Message 3.4. New Scenarios and Climate Projections

A new generation of Earth system models has produced an updated set of projections under a number of newly developed policy-relevant scenarios. A number of Earth system models have been run at significantly higher resolution (about 20-50 km) than the previous standard (about 100-200 km) for focused experiments to explore particular aspects of climatic changes, like tropical cyclones, that cannot be simulated by coarser-resolution models.

Key Message 3.5. Large Ensemble Simulations

New experiments from multiple climate models that capture both natural variability uncertainty and model uncertainty have improved our ability to understand and quantify expected climatic changes and the relative contributions of human-caused climate change and natural climate variability at regional scales (*high confidence*).

Key Message 3.7. Observations for Improving Process Understanding and Modeling

Recently deployed observing systems have reduced uncertainty in climate projections and improved our understanding of the climate system. Important advances in understanding stem from the application of new techniques that synthesize information from models and both new and existing observation networks and new data on past climatic conditions. (*High Confidence*).

Key Messages 3.4, 3.5, and 3.7 are framed differently from the rest; they are simply introductions and are about methods rather than impacts, adaptations, or mitigation. It may be more appropriate to move them to Front Matter (under the “Scenarios” section) or to Appendix 3 or merge them into the other key messages (e.g., Key Message 3.4 into 3.1, Key Message 3.5 into 3.2 or 3.3, Key Message 3.6 into 3.12). For Key Message 3.5, multi-model ensembles should be emphasized, as within-model ensembles can contain structural biases.

Additionally, Key Message 3.7 may be more appropriate for Chapter 2 (Climate Trends) or may not be necessary for NCA5. The explanation for emergent constraints is technically difficult, not well motivated, and ultimately not clear enough for the broader audiences. Because this section would have to be expanded considerably to be readable for general audiences, and this information is not used often in the report, chapter authors could consider eliminating this section.

Key Message 3.6. Extreme Event Attribution

The science of evaluating the effects of human-caused climate change on extreme weather and climate events has advanced significantly. Human influence has changed the frequency and intensity of some types of extreme events, and it is now possible to quantify climate change effects on specific extreme events. (*High Confidence*).

In Key Message 3.6, page 3-18, lines 9-11 indicate that advancements in methods that allow for the almost immediate attribution of extreme events is important. “Almost in real time” could be added to the last sentence of Key Message 3.6. Such rapid attribution has become almost commonplace in the popular media since NCA4. As discussed above, because of its importance, this section could be expanded and written more clearly for broader audiences.

Key Message 3.8. Water Cycle Changes

Many processes relevant to the water cycle have already begun to change and are projected to continue changing as the planet warms, including atmospheric moisture (*high confidence*), atmospheric circulation, patterns of natural variability (*medium confidence*), and the modulating role of vegetation on evaporation (*low confidence*). These drive changes in the intensity of precipitation in extreme events; snowfall, snowpack, snow melt; and the seasonal cycles of average precipitation and evaporation.

Key Message 3.8 is an overall important topic that is well written but should be better coordinated with Chapter 4 (Water). There are some specific comments on this section in Appendix A, but a general point that should be made is that if natural variability increases in the future, it will be more difficult to separate natural from forced variability.

Key Message 3.9. Changes in the Carbon and Biogeochemical Cycles

Understanding of the biogeochemical responses to human-caused greenhouse gas emissions has increased due to expanded observations and improvements in models, but uncertainty in the future evolution of the global carbon cycle remains high (*high confidence*).

Key Message 3.9 is well done in general, but the carbon cycle could be emphasized in the title rather than biogeochemistry, which may be too technical a term. This key message is not discussed in Chapter 1 (Overview). Chapter authors should consider how to make this key message relevant to the Chapter 1 (Overview) (as an indication of its relevance to the report as a whole) or remove it as it is too technical.

Key Message 3.10. Changes in Ocean and Cryosphere and Sea Level Rise

New observations, models and reconstructions have improved understanding of the drivers of regional sea level rise (*high confidence*) and how processes combine to cause sea level change at the coast (*medium confidence*).

Key Message 3.10 is a good introduction to the global problem, but the regional variability in SLR should also be emphasized.

Key Message 3.11. Atmospheric Circulation Changes

Atmospheric circulations that affect US regional climate are influenced by the global warming-induced expansion of the tropics (*medium confidence*). However, identifying the relative contributions of natural variability and human-induced climate change to changes in regional atmospheric circulation remains challenging.

Key Message 3.11 could be incorporated into another key message, as it does not directly describe a hazard that impacts humans or ecosystems. It is also another highly technical message, largely beyond broader audiences as presented. If more space is needed, this message may be the most dispensable in this chapter.

Key Message 3.12. Changes in Extreme Events

Human activities are affecting climate system processes in ways that are expected to increase the frequency and intensity of many, but not all, climate extremes, including heat waves, wildfires, drought, heavy rainfall, and coastal flooding (*medium to high confidence*).

Key Message 3.12 is important and could contribute to a stronger report if it were more often referenced. This key message could be expanded to be clearer for broader audiences.

Comments on Traceable Accounts

Chapter 2 of this report provides recommendations for traceable accounts and approaches to ensure consistency across NCA5. There are a number of specific issues with the traceable accounts section in Chapter 3.

First, this chapter's traceable accounts include a list of the expertise of the scientists writing the report, which is a good idea but inconsistent with other chapters. As recommended in Chapter 2, the NCA5 authors should decide whether such a description will be consistently included in all chapters. Additionally, other chapters describe the data gathering process that authors used to develop the chapter—stakeholder engagements, how authors communicated amongst one another, and frequency of author meetings—a section that is omitted in this chapter.

Second, the knowledge base should emphasize data sources and papers rather than the opinion of scientists. There are many examples in the traceable accounts of this chapter where opinions of scientists are emphasized. As an illustration of the problem, the traceable account for Key Message 3.1 states “Scientists have known the potential for climate change due to CO₂ emitted from human activities since the early 20th century and identified other human drivers, including non-CO₂ GHGs, land-use change, and aerosols by the 1970s (Ramaswamy et al. 2019).” “Scientists” should be replaced with references to scientific studies and note that studies start in the 1800s. The traceable account for Key Message 3.3 states “Because of the widespread agreement across generations of climate scientists that the local climate change response in a particular variable can differ substantially from the globally averaged response in that same variable since the earliest climate change assessments, there is very high confidence in this statement.” Per the confidence/likelihood language definitions presented in the Front Matter, the widespread agreement in the entire available knowledge base, not scientists, should determine the confidence intervals.

Third, traceable accounts should include many citations and can be more technical. For example, in the traceable account for Key Message 3.1, the paragraph on the methane sources (page 3-34, lines 22-29) does not include any citations. Traceable accounts on major uncertainties in regional variability (page 3-38, lines 27-35) should also include citations. Traceable accounts for Key Messages 3.8 and 3.9 do not include many citations. Traceable accounts should use the references in the body of the chapter to explain the evidence for the statements made in the key messages. Notably, because the traceable accounts are intended to be more technical than the body of the text, the traceable accounts are a good place to present many of the complexities and caveats that currently make sections of the text difficult for broad audiences.

Likelihood statements should be consistently used where quantitative evidence exists to support statements. For example, the description of confidence in Key Message 3.1 only mentions confidence for anthropogenic warming, when likelihoods are available from the literature. The traceable account for Key Message 3.2 also does not include likelihood, although well-vetted likelihoods are available from the IPCC. Most of the key messages in this chapter could include likelihoods and provide supporting evidence for the likelihood statement in the corresponding traceable account.

In the traceable account for Key Messages 3.4 and 3.5, it is not clear that it is necessary to say that there are new scenarios and large ensembles exist and are useful. The traceable accounts section could be reduced to focus on the parts of the chapter that have confidence and likelihoods that impact hazards.

The traceable accounts for Key Messages 3.2, 3.6, 3.11, and 3.12 are good examples and consistent with the recommended method; however, the key messages do not include likelihood statements. The traceable accounts for Key Message 3.8 should be similar in scope as the other traceable accounts. The key gaps section is informative but lacks citations.

Comments on Graphics and Boxes

Overall, the graphics are clear and well chosen. Most of the figure captions should be expanded; all figure captions should be self-contained and explain where the information comes from, rather than just provide a citation. Additionally, chapter authors should make sure that each figure is referenced in the text, and there are opportunities to better integrate figures into the supporting text.

It is not clear why there is an elephant in Figure 3.3. The figure appears to be taken from a PowerPoint slide. Consider cropping and moving the text to the caption so that the actual data presented is easier to read.

Figure 3.4 is extremely similar (and should be identical) to Figure 2.4. Both figures may not be needed.

Comments on Equity and Justice

Chapter 3 contains no reference to equity and justice. The introduction to this chapter should discuss the importance of hazards from climate change and how they might adversely affect already overburdened communities more than others. Some of the topics, especially regional changes and short-lived climate forcers, could be framed through an equity and justice lens.

Comments on Data and Analyses

Overall, the chapter does a good job of describing data and analyses in a consistent way. All the figures should have figure captions that are more thorough so that they are self-contained and clearly state what the figure means and why the reader should care.

Comments on Literature Cited

Overall, appropriate literature is cited. In some places, more citations should be included. Details are included in Appendix A.

CHAPTER 4: WATER**Summary**

Overall, the chapter meets the requirements of Section 106 of the GCRA, with exception of the requirement of special attention to projected changes and challenges 25 to 100 years in the future. The chapter covers an admirably wide range of water topics. However, the chapter neglects to discuss or at least make clear ties to several key issues and chapters: mitigation (despite important carbon footprints of water management), blue carbon, energy (beyond hydropower), human health, economics, urban water, transportation, and agriculture. The key findings are reasonably well stated and supported (with some exceptions discussed below) and the subject matter covered within each key message follows a logical order. However, the key message titles should be rephrased into short, informative statements (see examples below),

rather than headers, to more clearly portray the key message. Additionally, the traceable accounts do not document the key findings in a consistent, transparent, and credible way and require significant revisions.

The chapter is, in parts, written at too high a technical level. For instance, the explanatory text should include more references to “climate change.” The reader is sometimes required to assume or infer that phenomena listed are due to climate change, which may be confusing for broad audiences, as defined in Chapter 2 of this review.

The chapter also tends to focus only on “bad news,” even where the figures themselves illustrate broad regions where some areas may fare better than others. For example, Figure 4.3 shows broad swaths of the US where precipitation changes are projected to be small, and Figures 4.6 and 4.7 show a swath of the desert Southwest where increases in soil moisture and runoff are expected. Even-handedness in NCA5 will be necessary for credibility and to provide a basis for realistic adaptation planning. Therefore, where relevant, this chapter should address both the many challenges posed by climate change as well as opportunities (see Chapter 29 [Alaska] for examples) or areas where climate change may have the least impact. There is somewhat uneven attention to the inclusion of both confidence and likelihood levels for many statements, with only one or the other or neither listed for many statements.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

Notably, the introduction is a summary of the chapter, though not necessarily with the same citations or emphases. It does not attempt to motivate the chapter (e.g., “we all need water”), nor does it set the stage for the chapter by discussing the state of knowledge in NCA4. A revision to at least touch on both of those introductory topics would benefit readers of this chapter. References to NCA4 should be used in this introduction and liberally throughout the chapter to better focus on knowledge gains since the previous NCA.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The three key messages in this chapter reflect current knowledge about observed and projected impacts of climate change to water in the United States, followed by the challenges, opportunities, and methods to prepare for and address these impacts. They also identify emerging issues related to climate change. To help emphasize the key messages, the Committee suggests rewriting the titles as statements, rather than phrases, consistent with recommendations outlined in Chapter 2 of this report.

The text is written in a technical manner that, for the most part, communicates its findings effectively. However, some revisions may be needed to ensure comprehension by broad audiences. For example, “increasing the rates at which water is transferred to the atmosphere from open water, soil, and plants (Key Message 4.1)” is an unnecessarily opaque way of referencing what broad audiences will better understand as “increasing evaporation (and water use by plants).” As another example, in Key Message 4.2, “frontline of climate change” is a bit vague and might be replaced by “(particularly) vulnerable.” Beyond vocabulary, context needed by broad audiences is often missing—for example, the evapotranspiration (ET) discussion lacks

a relevant explanation. While it is helpful that ET is defined and climate impacts are discussed, the topic is missing the “so what” factor. Why should one care about ET when climate is discussed? Is ET good or bad? The chapter should not leave these questions up for interpretation, but instead ensure the text is clear and explanatory.

Adaptation and, especially, mitigation should be more fully discussed, specifically regarding water management (e.g., in Key Message 4.3). Adding a few sentences, along with references to other chapters where these issues are addressed more fully, might be all the chapter needs to introduce these important questions that policy makers are grappling with.

Comments on Specific Key Message Language

Key Message 4.1. Profound Changes to the Water Cycle

Climate change has caused profound shifts in the water cycle, creating risks for both people and nature (*high confidence*). Many regions of the United States are expected to see more precipitation and heavier rainfall (*likely, medium confidence*), resulting in increasing flood damage. However, warming will also increase the rates at which water is transferred to the atmosphere from open water, soil, and plants, increasing aridity and drought risk and threatening surface and groundwater supplies (*very likely, high confidence*). In many locations, snow cover is decreasing and melting earlier (*very likely, high confidence*), posing risks to agriculture and municipal water supplies, and natural systems (*high confidence*).

Suggested title: “The Water Cycle Is Changing, and Will Change, Profoundly.”

This key message provides a quick and generally readable synopsis of the range of water-cycle changes projected in terms of which water-cycle components will change or have already experienced change. The key message itself switches between changes already experienced (first sentence), projected changes (second and third sentences), and changes already experienced (fourth sentence), which weakens its impact. In each case (precipitation, evaporation, and snow), changes are already being experienced and are projected to increase, and the Committee suggests stating it as such.

The chapter opens with an infographic describing climate change threats to water quality. However, the key message does not touch on many of the issues presented nor does the supporting text.

Key Message 4.2. Rising Risks, Disproportionate Impacts

Natural and human systems have evolved under the water cycle’s historical patterns and cannot adapt quickly to rapid changes in patterns of droughts and floods (*high confidence*). Communities on the frontline of climate change—including many Black, Hispanic, tribal, Indigenous, and socioeconomically disadvantaged communities—are particularly at risk from changes to water quantity and quality due to the proximity of their homes and workplaces to hazards, limited access to resources and infrastructure, and cultural connections to water (*very likely, high confidence*).

Suggested title: “Water Changes Will Cause Different Impacts on Different Communities.”

This key message and its supporting discussion move immediately from the natural science focus of Key Message 4.1 to important issues of equity and justice disparities. Thus, this key message and its supporting discussion interject the issue of equity and justice disparities right from the start, elevating equity and justice issues. Notably, a reader could conclude from the wording of this key message that only the vulnerable and historically overburdened communities are at risk; the Committee suggests adding a few words in the first sentence to clarify that everyone will be impacted, but (second sentence) these communities face enhanced risks. Sanders et al. (2023) could be added as a reference to support this latter point.

Additionally, the first statement in the key message regarding the inability of human systems to adapt quickly to rapid changes in floods and droughts is an overstatement, belied by a hundred years of water-resources and flood-management activities. It is also likely contradicted by Indigenous knowledges. The Committee suggests the phrasing “struggle to adapt quickly” instead of “cannot adapt quickly.” As in Key Message 4.1, more attention to historical experience and responses to variability and extremes context in the supporting text would be useful for tempering or supporting this first sentence.

Key Message 4.3. Slow Progress Toward Adaptation

The ability of water managers to adapt to changes has improved with better data, advances in decision-making, and steps toward cooperation. However, infrastructure standards and water allocation institutions have been slow to adapt (*high confidence*), and efforts are confounded by wet and dry cycles driven by natural climate variability (*high confidence*). Frontline, tribal, and Indigenous communities are heavily impacted but lack resources to adapt effectively, and they are not fully represented in decision-making (*high confidence*).

Suggested title: “Progress Toward Adaptation Has Been Slow.”

This key message is well written and referenced, albeit limited somewhat by a few successful experiences thus far in overcoming barriers to planning and limited implementation of major adaptations. Both this key message and Key Message 4.2 highlight the observation that “adaptation is slow,” but it is unclear how this is measured. The Committee suggests providing an explanation for how adaptation is being measured either in the key message or in the traceable accounts. Also, Chapter 31 (Adaptation) should be referenced here for more detailed considerations of adaptation.

Comments on Text Supporting Key Messages

Key Message 4.1. Profound Changes to the Water Cycle. *Nuances of the projected changes often neglected:* Broadly speaking, the supporting discussion tends to list changes and impacts in geographically overbroad terms. For example, “many regions expected to see more precipitation” directly ignores the 25 to 30 percent of the country where declines are projected (Figure 4.3); the Committee suggests that slight wording changes such as “northern and eastern states will see more precipitation and southern states will see less” would make these statements more accurate and effective. Additionally, more significant rewording or cross-referencing relevant chapters would highlight more of the nuances or regional differences rather than implying that single projection applies to all regions equally. The overbroad descriptions also tend to discuss only the ensemble-means of projections (in Figures 4.3, 4.4, 4.5, 4.6, 4.7, and 4.9)

with no mentions of the ranges of outcomes indicated by the upper and lower percentile maps for each water-cycle variable shown in these same figures. If space allows, it would be helpful to include a discussion of these ranges in the supporting discussion for Key Message 4.1; at the very least, these ranges should be discussed in the corresponding traceable accounts. The Committee also suggests replacing “means” with “averages” throughout the chapter to enhance accessibility, and if medians are being used, they should include a brief explanation. Finally, it would be helpful throughout to clarify which changes (historical or projected) are precipitation-driven versus temperature-driven; uncertainties are larger regarding the former than the latter.

Reports of observed changes versus reporting of projected changes are intermingled and confusing: In several places—for example, the paragraph at top of page 4-12—the text switches between references to projections and already-observed changes in ways that confuse the audiences; more care should be given to distinguish the time frames (now or future) and basis (observations versus model projections) of the changes discussed throughout. Similarly, clarification of the distinction between projected climate changes (i.e., changes in climate) versus changes in terrestrial parts of the water cycle (i.e., groundwater recharge) induced by climate change would be useful.

Climate and water-cycle variability almost entirely neglected: This key message and supporting discussion largely neglects to mention either the natural variability that the trending and projected changes are embedded in, or the projections that variability is in many cases, projected to increase. Both aspects of variability are important context for interpreting the past and future changes reported and for understanding their likely practical impacts.

Flood non-stationarity treated as an “open question”: The large uncertainty suggested on page 4-11, lines 5-7, is either an overstatement of the cited work in the face of scientific consensus or is not accurately summarized. There is little doubt or lack of consensus that historical records of floods are an increasingly unreliable representation of current or future probabilities and magnitudes under climate change. The Committee suggests clarifying the meaning or the literature basis for this conclusion and bringing this statement and the key message assertion that there are major changes in flood damages to come into better agreement. The key message also frames its projection of increased flood “damages” in a way that appears to attribute that increase strictly to heavier precipitation. Flood damages, however, will depend on the success or failure of flood-risk management provisions and adaptations; flood risks are projected to increase in many places, but that is not the same as flood damages. Even flood risks are not entirely determined by the fate of heavy precipitation. Conversion of precipitation from snowfall to rainfall, increased durations and numbers of storms, and other non-climatic changes may contribute as much to increased flood risks and increased droughts as precipitation does. Additionally, the general tendencies of landscape drying may reduce flood risks in some locales. The Committee suggests that more care be given to connecting how the precipitation change projections translate to flood risks and then eventually to flood damages.

Changes in duration of extremes not mentioned: Future storms (and droughts) are described in terms of increasing frequencies and magnitudes; changes in storm durations are also projected and will have equally significant impacts (e.g., Gutmann et al., 2018; Kossin, 2018; Lamjiri et al., 2017; van Oldenborgh et al., 2018). In many settings, it is the duration that increases mortality (in the case of heat waves) or results in the largest precipitation totals. More discussion of drought durations and even multiple drought types might be warranted in this discussion.

Key Message 4.2. Rising Risks, Disproportionate Impacts. *Limited attention to causes and consequences of disparities:* As noted in the discussion of equity and justice issues below, this section rarely progresses beyond acknowledging that certain communities will be worse off and focuses even less on why and how to address the disparities than the key message itself. In this regard, the key message and this discussion should be brought into better agreement.

Current Colorado River issues provide useful examples that could be included here: This section should also include a discussion of drought-stricken Colorado River basin areas and tribes with water rights that have yet to be quantified as pressing examples of impacts and disparities. The issue of past (natural) megadroughts (most pressingly, in the Colorado River basin) is extremely important in a key message addressing extremes and impacts, and the discussion (e.g., on page 4-16) should explicitly point at the later discussion around Figure 4.19 or move the discussion and figure up to this key message, or even Key Message 4.1.

Key Message 4.3. Slow Progress Toward Adaptation. *Discussion of water disputes is oversimplified:* Not all water disputes are handled with litigation; this suggestion (page 4-21) is overly simplistic. It is especially not accurate when the statement is followed up with a statement about the Colorado River. The Colorado River has had many legal tools used to allocate water; this body of law is known as “the Law of the River” and is largely made up of a combination of agreements between states, nations, and smaller entities. It is true that climate change has stressed the capacity of the Law of the River to work as intended and there are problems with the body of law as well. For example, tribal rights to the water have, in several cases, not been quantified. The Law of the River was designed to provide and allocate water using assumptions based on pre-industrial times when flows were above average and tribal rights were unaccounted for. Now, given the historic megadrought-induced water shortages and snowpack reductions, the system is stressed and is in rapid and continuing decline. A more accurate sentence here might read (see suggested citation, Garofalo, 2019):

Climate change impacts to water supplies can result in competition, collaboration, or conflict. Tools may include litigation, administrative proceedings, treaty negotiations, compacts, and/or cooperative agreements, among others. Under current severe drought conditions, water rights holders in the Colorado River Basin, including Mexico, tribal nations, states, and other interested parties are struggling to adapt under the existing legal framework—one that was mistakenly based on the assumption of continued sustained flows and on an above average historic estimate of total water available to apportion. While some of these efforts include tribes....

Natural variability context scarcely mentioned until end of chapter: The discussion of natural variability in context of the Colorado River Compact (page 4-23) is an important addition but appears very late in the long list of chapter-specific trends. The final sentence (page 4-23, lines 17-19), with its allusion to the crucial mix between natural variability of “wetness” versus warming-induced flow reductions, is a key problem that was ignored throughout the earlier parts of the chapter and that will be faced in most parts of the country. The Committee suggests the chapter authors highlight and expand on this issue earlier under either Key Message 4.1 or Key Message 4.2.

Other equity- and justice-impacted communities are largely ignored: The subsection on tribal and Indigenous communities (page 4-25) is a good start, albeit drawing mostly from a

single reference (Fillmore and Singletary, 2021). As noted below, this use of a separate subsection to address these issues means that tribal issues that are shared by other nontribal communities are highlighted, which is laudable, but without acknowledgment of issues and barriers shared by other communities.

Water quality issues under-addressed: The finding (from Fillmore and Singletary, 2021) that water quality information is the most pressing need (page 4-25, line 5) among the western tribes they polled suggests that perhaps more discussion and attention to water quality issues, following Figure 4-2, is in order in the chapter.

Lack of technical capacity is the real limitation on adaptation: The lack of access to downscaled projections on page 4-25, lines 19-20, is less of an issue since past NCAs with the advent of high-resolution national coverage and modern internet resources in most areas; it is not the case that such projections are “rarely” available now or are the limiting factor on adaptation planning and activities (Findlater et al., 2021). What is insufficiently available now are the technical skills, expertise, and computing resources necessary to put those available projections to use in non-research institutions. Furthermore, rather than access, there is a lack of consistent guidance on whether and how projections should be incorporated into planning.

Comments on Traceable Accounts

The Chapter 4 (Water) traceable accounts do not include citations. Additionally, the traceable accounts make some stronger and different assertions, and express more confidence in some instances, than the text in the body of the chapter. Additionally, the purpose of traceable accounts is to support *how* the authors arrived at their confidence and likelihood statements. While the traceable accounts are well written, they *should include* citations to adequately support the claims made in the text. Because the traceable accounts are lacking citations, the chapter does not identify and provide sufficient context for embedded content in the traceable accounts section. Thus, the traceable accounts should be revised to demonstrate *which* references support *each* confidence and likelihood statement.

As noted above, water quality, especially the mechanisms by which it will be affected by climate change, is neglected in this chapter. Figure 4.2 nicely summarizes many of these mechanisms, but this figure is inadequately discussed and only referenced in passing in the chapter. Some of this missing attention to water quality may reflect the relatively thin literature on the topic, but this relative lack of research on water quality with relevance to the impacts of climate change should be highlighted in the traceable accounts.

The summary (on page 4-9) of projected western United States groundwater-recharge changes, “decreas(ing) natural recharge across much of the West,” which is stated without a confidence level, is an inaccurate depiction of the projections. The statement is contradicted by the key figure (6) in the primary citation (Niraulta et al., 2017), which shows different outcomes in different regions, over different time frames, and from different climate models. Thus, confidence should be relatively modest at present, indicating that this is an important research gap.

The list of ways that warming will influence snow processes and implied snow-fed runoff processes is missing one of the more important and straightforward changes to come: the fractions of many historically snow-dominated river basins that receive rainfall (and generate rapid rainfall runoff in large amounts) instead of snowfall will increase dramatically, thus increasing the flood flows and early runoff. The regions that will be impacted are more pressing

than the changes in rates and frequencies of rainfall versus snowfall in determining these enhanced volumes of runoff and winter floods.

Finally, regarding the continued discussion of snow processes on page 4-27, several important articles should be included (also in Key Message 4.1) to bring this discussion up to date: the excellent up-to-date literature review by Siirila-Woodburn et al. (2021), and a wide-ranging evaluation of snowmelt sensitivities by Ban and Lettenmaier (2022), Gordon et al. (2022), and Harpold and Brooks (2018).

Comments on Graphics and Boxes

The figures are generally effective and appropriate. For the most part they are simple, captioned well, and useful to wide audiences. In most cases, though, the figures should be better integrated into the body of the text (as most are dispatched therein with a single sentence each or less) to further motivate or expand on points made in the text. The Committee highlights more specific suggestions below.

Figure 4.2 is an effective and accessible infographic that presents primary pathways by which climate can impact water quality. If possible, the Committee suggests constructing a corresponding infographic for water quantity and/or supply.

Figures 4.3, 4.4, 4.5, 4.6, 4.7, and 4.9 are an excellent sequence of similarly formatted graphics showing projected midcentury ensemble mean, 20th percentile, and 80th percentile changes in various water-cycle components. The captions include a wide range of useful “examples” but are stated strictly in terms of Representative Concentration Pathway (RCP) 4.5 conditions. However, this is inconsistent with what the map labeling implies is shown in the maps. Additionally, the text states, “average of all projections” and “average of 10 projections,” but does not define how many are included in the “all” referenced. The Committee suggests fixing the labeling or the captions to make sure they are aligned.

Figures should be able to stand alone, and the captions should both tell the reader the meaning of the figures and describe what the figures show. The ensemble-average projections are covered in the text but treated as the projections; it would be better to acknowledge and at least allude to the ranges of changes indicated by the 20th and 80th percentiles shown. (In the caption of Figure 4.4, “the projections ... are expected to decrease” is an odd and redundant phrasing.)

Comments on Equity and Justice

The authors include some attention to equity and justice in the chapter; however, it would benefit from stronger framing of equity- and justice-related issues in the introduction, including a definition of water justice. The Committee also suggests integrating historical and systemic drivers of preexisting inequalities that may be entrenched or exacerbated by climate change (i.e., describe how the changes to water quality, accessibility, reliability, and availability are related to the social context of water justice (i.e., resource distribution, decision-making dynamics, power relations). The Committee appreciates the attention to the importance of data access.

Currently, the chapter authors focus primarily on Black, Hispanic, tribal, Indigenous, and socioeconomically disadvantaged communities, and occasionally on distinctions between rural and urban communities and settings. Key Message 4.2 could benefit from a discussion on the disproportionate impacts to drought-stricken Colorado River basin areas and tribes with water

rights that have yet to be quantified. Additionally, many of the discussions of equity and justice issues would be improved by pointing to other chapters and sections where the issues are more fully addressed.

Notably, there is no mention of gender issues regarding water availability, despite the glaring fact that, from as recently as the November 25, 2022, *Eos*: “according to the United Nations, climate change and its effects are not gender neutral: Women and girls are hit the hardest, as the climate crisis deepens already existing gender inequalities,” with even more acute disparities across the range of LGBTQ+ communities (e.g., Goldsmith and Bell, 2022; Goldsmith et al., 2022; Vinyeta et al., 2016). Pacific Island communities are also not mentioned in this chapter. In fact, the word Hawai‘i appears once, and only to explain that it is not in a specific image. There is no mention of equity issues likely associated with examples like Figure 4.14.

The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible. Finally, specific gaps in equity- and justice-related literature with respect to the chapter focus should be noted.

Comments on Data and Analyses

The chapter summarizes existing literature rather than employing data and statistics, and so few comments on data and analyses are applicable.

Figures 4.3, 4.4, 4.5, 4.6, 4.7, and 4.9 map ensemble average and 20th/80th percentile projected changes in selected water-cycle variables. Unfortunately, only the average changes are discussed and sometimes in the context of projected outcomes. The ranges of projections indicated by the 20th and 80th percentile maps should be incorporated into the discussions, and into the uncertainties and likelihoods as described in the chapter.

Comments on Literature Cited

Many references cited throughout this chapter are older than ten years and thus predate NCA4. Where possible, older references should be replaced with newer literature, or, better still, selective lists of references building from the earlier reference should be used to demonstrate the growing body of literature on the topic. Additionally, much of the discussion and literature cited is noticeably western US-oriented, and additional newer references for eastern US issues should be included.

Occasionally, the literature cited does not reflect as broad a statement as it is cited to support; examples are offered above (e.g., the use of the Niraulta et al., 2017 paper in Key Message 4.1) and in Appendix A. Another example is from the discussion on drought (page 4-17, lines 14-16): “Drought conditions have historically resulted in increased groundwater pumping, a practice projected to increase with climate change (Bloomfield 2019; Hanson et al. 2012; Scanlon et al. 2012).” The Bloomfield article is based on case studies in the United Kingdom and the other references are focused on specific regions, rather than the United States as a whole. The chapter should reflect this nuance in its summary of the literature.

CHAPTER 5: ENERGY SUPPLY, DELIVERY, AND DEMAND

Summary

The Committee found Chapter 5 (Energy Supply, Delivery, and Demand) to be strong overall. The chapter largely meets the requirements of Section 106 of the GCRA. The key messages are clearly stated and are thoroughly supported by the detail provided within the chapter, and the findings are mostly documented in a consistent, transparent, and credible way. However, the traceable accounts require revisions to include citations and more details about how and why confidence and likelihood were determined based on the knowledge base. The chapter could also better integrate issues of equity and justice inherent in the US energy system. Additionally, the chapter does contain some technical language that may be difficult for the broadest possible audiences to follow; however, this is hard to avoid and still maintain clarity and accuracy for a technical topic like energy. The Committee provides suggested additions for topics and citations below.

The standout advancements in energy since NCA4 include improvements in clean and smart energy technology deployment, progress in climate modeling and planning methodologies, and increased equitable access to clean energy. These are clearly noted by the authors. However, reductions in coal use in the United States since NCA4 deserve mention as well.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

Although the introductory text provides appropriate context, the Committee has three suggestions for additional context that could be added. First, chapter authors could consider discussing energy subsidies and other relevant government interventions including the recently passed Bipartisan Infrastructure Law and Inflation Reduction Act, mentioned in two other chapters (Chapters 25 [Northern Great Plains] and 32 [Mitigation]). Another important development is the use of litigation, particularly against the fossil fuel industry (Setzer and Higham, 2021). Similarly, natural gas bans in cities and bans on electricity produced with coal by some states (e.g., California, Oregon) should also be mentioned (Stevens and Lamberrmont, 2021). Second, the introduction should mention fossil fuels by name and relevant expectations for the fossil fuel industry such as reducing methane leakage/venting. Third, the chapter would benefit from a discussion of international topics related to energy such as the global energy supply chain and a more pointed discussion of critical minerals and supply chain concerns, as these topics are important in the context of both climate change and global change. Other international tensions relevant to US energy worth mentioning include nuclear energy (e.g., instability of Russian reactors); use and international trade of coal (i.e., among the United States, Germany, China, and Russia); production, demand, and trade of natural gas and oil; and imports, exports, and scaling up of solar panels. Topics not included in the chapter should also be mentioned in the introduction.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The key messages in this chapter reflect the current knowledge base of observed and projected impacts on energy systems in the United States as well as the challenges, opportunities, and ways to address the risk in the energy systems. The key messages are written in a consistent and appropriate way and reflect supporting evidence well. However, it is not always clear to which clauses of individual sentences the confidence and likelihood rankings apply. To provide credibility, it is important that each assertion includes a confidence and, if applicable, likelihood ranking (see Key Message 25.1 for an example). The chapter prioritizes newer literature (since NCA4) and appropriately includes citations after each assertion.

Overall, the label, title, and message for each key message are appropriate, and consistently use both confidence and likelihood language. Key Message 5.3 should convey whether current progress is sufficient to address the current and future impacts of climate change.

Comments on Specific Key Message Language**Key Message 5.1. Climate Change Threatens Energy Systems**

Energy supply and delivery are at risk from climate-driven changes, which are also shifting demand (*likely, high confidence*). Effects on energy systems are expected to increase with projected increases in the frequency, intensity, duration, and variability of extreme weather events (*likely, high confidence*). Potential impacts include damages to infrastructure and operations and resulting effects on human lives and livelihoods from extreme precipitation, extreme temperatures, sea-level rise, and more intense storms, droughts, and wildfires (*likely, high confidence*).

Key Message 5.1 summarizes the observed and projected impacts and disruptions on energy systems including energy supply, energy delivery, and energy demand. The key message is concise, appropriate, and consistently uses assessments of both confidence and likelihood. In the text supporting the key message, there are great examples and citations throughout, including noting positive impacts of climate change (e.g., Alaska offshore production). The citations and logical order of topics support the confidence and likelihood statements.

Key Message 5.2. Compounding Factors Affect Energy System and Community Vulnerabilities

Interconnected effects of changes in technologies, policies, and markets increase the potential vulnerabilities of energy systems and communities to climate change and extreme weather (*likely, high confidence*). Compounding and cascading hazards related to energy systems and additional stressors such as cyberthreats and pandemics create risks for all but disproportionately affect underserved and overburdened communities (*likely, high confidence*).

Key Message 5.2 summarizes the observed and projected impacts from compounding factors such as resource constraints (material and workforce, supply chain, siting new infrastructure), cybersecurity threats to the power grid, vulnerable communities and equity, and cascading hazards. The title of this key message is informative, the message is well written, and

the topics discussed flow logically. In the text supporting the key message, citations are recent and support the overall findings (confidence and likelihood statements). Terms are defined in the text where necessary to help all readers understand.

Key Message 5.3. Progress Continues on Enhancing Energy System Resilience

Investments are being made to increase the resilience of the energy system, and opportunities exist to build upon these efforts (*likely, high confidence*). Progress includes improvements in energy-efficient buildings; technology to decarbonize the energy system; advanced automation and communication and artificial intelligence technologies to optimize operations; climate modeling and planning methodologies; and efforts to increase equitable access to clean energy (*likely, high confidence*). An energy system transition emphasizing decarbonization and electrification would require significant investment in new generation, transmission, distribution, and fuel delivery (*likely, high confidence*).

Suggested title: “Efforts to Build Energy System Resilience Are Under Way.”

Key Message 5.3 summarizes the existing investments to increase the resilience of the energy system and highlights the opportunities to further strengthen these efforts and resilience. The analysis is supported by recent literature. However, the term “resilience” given its central role in this key message should be clearly defined. Additionally, this key message should also indicate whether current progress and trajectories are sufficient to enhance energy system resilience to deal with future potential damages from climate change. The Committee suggests the key message title not use “continues on,” which is not clear. The Committee provides a suggestion for an alternative title above. Lastly, the second sentence includes many claims, and it is unclear if the confidence and likelihood statement pertains to only some or all of these claims.

Comments on Text Supporting the Key Messages

Key Message 5.1. Climate Change Threatens Energy Systems. This chapter describes several impacts of climate change on the United States energy system, but it omits how the total demand for energy could change. There is a detailed analysis of the electricity system but there are not similar details for “primary” energy resources like coal, oil, and gas demand.

The key message is about climate change but most of the examples are about the effects of weather and weather-driven events like wildfires under current conditions (or projections) without a clear message about changes in recent decades. This key message is also missing the distinction between natural variability and climate changes; clarity could be added by modifying a few sentences throughout the chapter. Examples could be more clearly communicated by discussing them separately from the projections as well as by creating an additional section for examples associated with climate change. Permafrost impacts in Alaska are not discussed, including issues like methane leakage, a key challenge in the oil and gas industry.

The text supporting this key message should also note the impact of policy responses to climate change on the energy system. An example could be price changes due to imposing a price on carbon, or higher overall energy costs as the infrastructure and makeup of the energy system changes. The Committee suggests adding a discussion about what oil and gas are used for besides electricity to clarify that even in a “transitioned” world their development and delivery is still relevant, and therefore the inclusion here makes sense to audiences. It is also important to

note where regional differences exist across the country—for example, electricity generation and water availability is a topic that may be more relevant in the west and mountain west than in the east—and there should be cross-references to those relevant regional chapters. Given limitations of the word count, the Committee suggests that the technical details for the section of “Oil and Gas Delivery” be moved to the traceable accounts.

Key Message 5.2. Compounding Factors Affect Energy System and Community Vulnerabilities. Regarding vulnerable communities and equity, there is a lack of discussion about the distributional impact to those who used to work in the traditional fossil fuel sector but have been displaced due to the energy transition. Other compounding factors that are missing include inflation and geopolitics, which can impact energy prices. The Committee suggests adding cross-references to other chapters (e.g., Chapter 19 [Economics]). In addition, consumer behaviors are not discussed, which may impact the adoption of new energy technologies and influence the actual performance of these technologies. The text supporting Key Message 5.2 may be slightly technical for broad audiences, so the Committee suggests defining terms specific to the energy industry in the introduction. This section is also an important opportunity to note the emerging evidence that CO₂ affects human cognition at levels observed in buildings in cities, including school classrooms (Du et al., 2020; Karnauskas et al., 2020; Wang et al., 2021). This addition may not involve much text, but instead could mention the topic and reference Chapter 15 (Human Health). The impact of CO₂ on human cognition levels has been missed in previous reviews and even in IPCC AR6.

Additionally, the Committee suggests touching on the causes of resource constraints, particularly regarding the critical minerals supply chain and the implications for the energy sector (Ballinger et al., 2019; Li et al., 2020). The section could also use more detail and citations. Similar comments are made in Chapter 32 (Mitigation) review, and therefore, there may be an opportunity for both of these chapters to cross-reference one another on this topic rather than duplicating information, which should help minimize the number of additional words. Given limitations of the word count, the Committee also suggests that the technical details for the section “Compounding and Cascading Hazards” can be moved to the traceable accounts.

Key Message 5.3. Progress Continues on Enhancing Energy System Resilience. Reductions in coal use in this country since NCA4 deserves mention. It is a great story of mitigation in action but should be couched in the context of the fuel switching driven by natural gas price advantage and not just renewables. Related issues of equity and their effects on communities deserve attention as does the differing approaches of states (e.g., Righetti and Stoellinger, 2021). The text in this section would also benefit from adding a few sentences detailing the Inflation Reduction Act changes to the tax credit scheme that emphasize worker protections and vulnerable population protections. The short discussion of energy storage in this section omits developments of alternative materials beyond lithium. Similarly, the idea of recycling battery materials or the circular economy should be explored. Given the limitations of the word count, the Committee suggests that the technical details for the section “Automation, Information Technologies, and Grid-interactive Efficient Buildings” can be moved to the traceable accounts.

Comments on Traceable Accounts

Generally, the chapter does a decent job in its traceable accounts section. Literature citations are highly variable, and the Committee suggests consistently adding citations after

sentences that assert that there is literature, policy, or law supporting a claim. For example, the statement, “The impact of climate change on global warming and sea-level rise is well established in the peer-reviewed research and supporting publications...” (page 5-19, lines 28-29) should include references. Overall, literature citations are lacking in the traceable account for Key Message 5.1, rare for Key Message 5.2, not uncommon in Key Message 5.3. This is primarily an issue in the “Description of the Evidence” sections for each key message. Adding appropriate citations would help appropriately identify and provide sufficient context for the embedded content.

The traceable account for Key Message 5.2 is quite long, though it is effective in describing the omissions in the literature and the lack of available data due to classified information. The traceable account for Key Message 5.3 should describe how authors arrived at their prescribed likelihood statements, as is done for the other key messages.

Comments on Graphics and Boxes

The graphics are effective and appropriate but could be better integrated into the text. Some are too busy and try to do too much without enough explanation in the captions, making them somewhat inaccessible. Specific suggestions are described below.

The title of Figure 5.1 is different than the title embedded in the image. The Committee suggests making them the same or omitting one. Additionally, the text in the small boxes is hard to read and there are too many boxes, which is distracting. The Committee suggests reducing words if possible or organizing the text in a table under the image with numbers to identify where the “pipelines,” “thermoelectric power plants,” etc. appear in the image. Figure 5.1 should also be updated to reflect permafrost changes, such as on pipelines.

For Figure 5.2, the Committee suggests using “electricity demand” instead of “energy demand” in the titles because this figure is only about electricity. Authors should also clarify the word “hot” in the figure where it describes the scenario.

In Figure 5.7, the Committee suggests explaining in the caption the difference between the two images, and why the “renewable” electricity generation graph (b) shows coal—is it biofuels and carbon capture utilization and storage?

Comments on Equity and Justice

Equity and justice principles are somewhat addressed throughout the chapter, however, given the inherent environmental injustices in the energy sector, the chapter should more clearly emphasize these principles. Below, the Committee identifies several equity and justice issues that could be expanded or discussed to enhance the chapter.

The chapter would benefit from defining “energy justice,” including distributional (distribution of benefits and burdens across populations), procedural (who is included in energy decision-making processes to ensure that energy procedures are fair, equitable, and inclusive), and contextual (understanding of historic and ongoing inequalities) aspects. The key energy justice-related terms should be integrated, including energy insecurity, energy burden, energy equity, heat equity, and just transition. There are additional equity and justice issues relevant to this chapter. For example, in the context of energy, race is the primary indicator for the placement of toxic facilities in the United States (Mohai and Saha, 2015). The chapter should

also include a discussion on energy lifecycles as they relate to environmental justice, including extraction, production, consumption, and waste.

The chapter lacks an important discussion on energy industry workers who have based their generational livelihoods on fossil industries (e.g., coal and mining industries) and will likely face a lack of work or the need for training to move into new industries or technologies. A related discussion of public acceptance could be included (e.g., Armstrong, 2021; Sharpton et al., 2020). The issue of how expertise in the oil and gas community is relevant to many challenges in the renewable energy sector is not explored. Considerations of the workforce are the intertwined health issues. The Inflation Reduction Act emphasizes worker and vulnerable populations protections through a new two-tiered tax credit system that could be mentioned in Key Message 5.3. There should also be a discussion of inequitable adoption of new energy technologies among groups of consumers (e.g., adoption mainly happens in wealthy neighborhoods).

More focus is needed on the just transition literature and related equity complications. For example, there should be a discussion on the transition to lower-carbon sources of energy without specific efforts to ensure an equitable transition; as a result, everyone will not benefit equally (Carley and Konisky, 2020). Also, the chapter could mention that frontline communities of a just transition are diverse and, in addition to race and ethnicity, include those who work in legacy energy industries; non-extractive communities that rely on fossil fuels (i.e., those that host power plants or manufacture combustion engines); those who face enhanced short-to medium-term energy insecurity; as well as those who will lack access to new employment opportunities, involvement in decision making, and advanced technologies.

Finally, there should be a review of efforts to address disparities and build adaptive capacity including workforce and economic development, energy assistance programs, access to technology, community engagement in decision-making processes, and identification of barriers to a just transition. Associated data gaps should also be pointed out, such as who is on the frontline of a just transition, as well as the effectiveness and design of technology access, workforce, and economic development programs.

The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible. Finally, specific gaps in equity- and justice-related literature with respect to the chapter focus should be noted in the text or traceable accounts.

Comments on Literature Cited

This chapter cites literature from well-respected journals and agencies, most of which were published since NCA4. However, the Committee suggests also including other sources of information and literature that make up the knowledge base.

Other Recommended Changes

The Committee suggests discussing regulatory barriers that impede the commercial build-out of new technologies—for instance, the unclear regulatory framework for CO₂ or hydrogen pipelines (e.g., Garofalo and Lewis, 2020). This chapter is primarily focused on impacts on the energy systems and energy system resilience but lacks a detailed discussion on mitigation and adaptation moving into the future. The Committee suggests adding the role of mitigation

measures in addressing climate change to Key Message 5.3, as well as referencing Chapter 32 (Mitigation) where these efforts are discussed.

CHAPTER 6: LAND COVER AND LAND-USE CHANGE

Summary

This chapter reviews climate change impacts related to land cover and land-use change (LCLUC). The chapter is strong and essential for the framing of the broad objectives of NCA5 and meets the requirements of Section 106 of the GCRA but could be improved with a few key modifications. This chapter is important because LCLUC is an important element of global change research, though the chapter could more explicitly include projections of trends 25 to 100 years in the future. This chapter is written at an appropriate technical level, especially for decision makers, and supports an appropriate balance of evidence against scientific uncertainties. A chapter on LCLUC was also included in NCA4 and the chapter in the draft NCA5 report brings new materials, especially an interesting focus in Key Message 6.3 on constraints to the array of available land-use choices resulting from future land-based mitigation needs.

The chapter provides a working definition of land systems, which encompasses both land cover and land-use. However, the text frequently departs from a disciplined use of the definition in favor of generally referring to land-use or ecosystems. The chapter would benefit from a discussion that is explicitly framed around land cover and land-use. There is a focus on developed land as an important focal point, which is useful since this land cover class is less well addressed in other chapters. However, it is misleading to emphasize its importance by referencing its rate of increase, when in terms of total area change, developed land may be less important than other land cover changes, such as agriculture and forests. NCA4 suggested the developed land category is far less important than emphasized in this chapter. The precise analysis of LCLUC statistics should be reviewed here and cross-checked with other chapters. Similarly, estimates of emissions and removals should be reviewed, made consistent with other chapters, and standardized using an established source such as the US National Inventory (EPA, 2022). The chapter could be improved with additional text on rangelands and grasslands, particularly given their importance in NCA4. Revisions are needed to better integrate equity and justice into the chapter. The examination of future LCLUC projections is useful, but the chapter uses outdated Special Report on Emissions Scenarios (SRES) emissions scenarios. Lastly, the chapter could benefit from more reference to, and use of, emerging concepts and literature of land change science.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction presents several figures; however, it should also introduce the key message themes. It would also be useful to expand the discussion on the importance of LCLUC in analysis of climate change and climate change mitigation and adaptation. Other chapters note that climate change impacts are complicated and exacerbated by land management; it would be

appropriate in this chapter to go into more detail about the nuance interactions of climate change and LCLUC. There is an emerging field of land science with references that could be added (e.g., Chowdhury and Turner 2019; Gutman et al., 2004; Rindfuss et al., 2004; Turner et al., 2007, 2020). One potential area of discussion is the concept that LCLUC influences both the radiative aspects of climate change (i.e., GHG emissions and removals) and the water-energy balance through surface conditions change (i.e., albedo, latent and sensible heat flux). These dynamics and their interactions and feedbacks with climate are complex and not always obvious—for example, in some conditions, biotic carbon sequestration can lead to additional warming. It is important to distinguish this chapter on LCLUC from other chapters on forests, ecosystems, and agriculture, and by drawing on the land change science literature. Reference to, and drawing from, Chowdhury and Turner (2019) and Turner et al. (2007, 2020) may be useful.

Comments on Key Messages, Supporting Information, and Traceable Accounts

This chapter discusses climate change impacts on LCLUC. The chapter authors outline the definition of land systems, which is comprised of two components: land cover and the way land covers are used by humans, or land-use. The chapter does a good job outlining the importance of land systems because it generally covers the most important domains of impact as well as where most mitigation and adaptation will take place. Although the chapter introduction starts with a defined framework for analysis (i.e., land cover and land-use), the key messages and the discussion on potential future options for adaptation does not adhere to this framework. While the emphasis of this chapter is to examine climate change impacts on land cover, with a focus on domestic concerns, it would be useful to include a brief discussion of how land cover changes in turn drive climate change, such as when deforestation results in GHG emissions or changes in water or energy balance. Furthermore, briefly discussing the idea of global teleconnections between land cover changes in other parts of the world and climate change impacts here in the United States would provide the audiences a better understanding of the complexities of interactions between land cover and climate change. A good example of these teleconnections is the hydroclimatological teleconnection between deforestation in the Amazon and domestic climate change impacts. Among other facets, this would help give the audiences a better understanding of the global context for land cover change mitigation.

There are some early conceptualization issues as well—for example, representing important land cover changes based on percent change rather than absolute magnitude gives a false impression that expansion of developed land cover is most important, which is not accurate. The key messages are appropriate and presented in a logical way, especially Key Message 6.3 on future projections. However, it would also be useful to note that LCLUC is by itself an important global change, which will interact with climate change to exacerbate, or perhaps ameliorate, the impacts. This chapter focuses on climate change influences on infrastructure, which is a good message for audiences because of its obvious economic impact. Key Message 6.3 on restricting future decision options is very important, and perhaps could be given more emphasis overall. Key messages are often missing likelihood statements, and it is not clear that the chapter authors approached confidence and likelihood in the same way as other chapters, nor as specified in the Front Matter.

The chapter could be improved by adding more on grasslands, rangelands, and pastures concerning recent increases in fire. One of the dominant land covers in the United States, rangelands, has important climate impacts, such as fire and new evidence on invasive species

from climate change. Relatedly, there should be more discussion on the wildland-urban interface (as well as other land cover/land-use interfaces), which would help frame this chapter in a way that is distinct from other “land cover” chapters.

Similarly, with other chapters, land cover changes are driven by both climate change and natural variability, which should be attributed separately. Early in the discussion of Key Messages 6.1, there is a statement that the United States sink for carbon is dominated by increased CO₂ concentrations in the atmosphere over the influence of LCLUC. The next sentence cites Pugh et al. (2019), which comes to a different conclusion, unless the CO₂ fertilization influence on regrowth is taken into account. This idea contradicts Chapter 7 (Forests), which attributes the sink to harvested wood products and regrowth. All references to carbon budgets and GHG inventories should be reconciled, standardized, and consistent with current literature, common terminology, and other chapters. In addition, the chapter does not acknowledge the role of natural variability in the key messages. At local levels, natural variability may play a larger role than climate change.

Comments on Specific Key Message Language

Key Message 6.1. Land System Goods and Services

Climate change has increased the intensity and frequency of extreme rain, droughts, fires (*high confidence*), and floods (*low to medium confidence*), posing increased risks for roads and other infrastructure, agricultural production, forests and biodiversity, and human health (*high confidence*). The role of forestlands as carbon sinks is at risk from climate-driven wildfire (*high confidence*). Climate change has disrupted the ways that people interact with the landscape for spiritual practices, recreation, and subsistence (*high confidence*).

Suggested title: “Climate Change Will Increase the Threat to Infrastructure and Loss of Important Land-Based Goods and Services.”

In order to acknowledge the role of natural variability discussed above, Key Message 6.1 should include “in some places and times” to recognize that climate change does not cause these hazards everywhere, all the time.

Key Message 6.2. Land System Resilience

Resilience allows natural and built systems to maintain their basic character and functions in the face of change, supporting the continued delivery of goods and services. Changes in climate and land use affect the resilience of land ecosystems and thus the fate of the services they provide (*high confidence*); for example, increasing drought reduces the ability of forests to store carbon. Climate and land-use change interact, and these interactions present challenges as well as opportunities for maintaining ecosystem resilience (*high confidence*).

Suggested title: “The Combination of Climate Change and Land-Use Change Will Lower the Resilience of Land Systems to Floods, Droughts, and Other Challenges.”

Given that the term “resilience” plays a central role in this key message, the Committee suggests including a clear definition of the term.

Key Message 6.3. Future Land-Use Options

The future of land use in the United States will depend on how energy and agricultural technology evolves, how the climate changes, and the degree to which we prioritize climate mitigation and adaptation in land-use decisions (*very high confidence*). Continued crop yield improvements and reductions in demand for animal-sourced foods could free agricultural land for other uses, depending on the ability to maintain agricultural system resilience (*low confidence*). Decarbonization will require a large expansion of solar and wind energy generation and transmission infrastructure (*high confidence*) and may involve large land-use changes toward reforestation or biomass crop cultivation (*low confidence*).

Suggested title: “Future Land-Use Decisions and Options Will Increasingly Focus on Climate Mitigation and Adaptation at the Exclusion of Other Considerations.”

This is an important key message, and it has been framed well by the authors. To distinguish this chapter from others on individual land covers and sectors, it may be useful to bring in the concept of nature-based solutions, or natural climate solutions, which will heavily focus on the land base. The chapter authors could use literature such as from Seddon et al. (2021).

Comments on Text Supporting the Key Messages

The supporting text is written well and cites references well. However, the Committee has two major concerns. First, the chapter provides the land systems framework in the introduction, but the text supporting the key messages reviews individual sectors or land covers (e.g., forest, agriculture, developed land). It would improve the chapter and distinguish it from other chapters if the text adhered to the overall land systems framework or as noted, a land change science perspective (see references above). Laying out the broader framework of LCLUC importance overall, the changes observed in land cover and land-use separately, and the drivers and impacts of LCLUC would improve the usefulness of the chapter. A few cogent examples would then be useful to demonstrate ideas discussed without having to cover all cases of specific LCLUCs.

Second, it is critically important to accurately report numbers and data and use a standard source consistently across all chapters. It is important to adhere to one type of statistical unit (e.g., square miles or acres but not both) and perhaps consider change metrics expressed as absolute values (not percentages) with specificity on whether the change is net or gross.

Key Message 6.1. Land System Goods and Services. The section lays out some important considerations. The land system is important for the provision of goods and services and economic vitality. This key message could provide more background for Key Message 6.3, which is the most important component of this chapter. This key message does well to point out the economic implications of climate destabilization of built infrastructure, and it may be useful to examine the same for other infrastructure aspects such as agriculture—for example, excessively wet spring conditions prevent planting.

The impact on goods and services is noted, but the range of specific examples of impacts across various sectors would be too numerous to delineate them all in this chapter (e.g., agriculture, forests). Thus, the chapter should present a few cases as examples, perhaps using a

box. It would be useful to report on studies that have looked at the economy from a larger perspective; for example, see Kubiszewski et al. (2020) and Weiskopf et al. (2020).

Key Message 6.2. Land System Resilience. This key message demonstrates how climate change will influence the ability of all land systems to mediate impacts, which is useful. This framing is helpful for this chapter because there are other chapters that treat ecosystems, forests, and agriculture individually. It would be useful if there were more cross- references to other chapters. The discussion of economic impacts is useful. There is also a discussion on how multiple interactions between land cover and use are important. However, Figure 6.7 is bulky and defeats its purpose. Perhaps some case studies or examples would be a better substitute.

The emphasis on the importance of development needs reconsideration because although it is a rapidly changing land cover, its overall magnitude is less than some other land cover types. The discussion of interactions in the land system is useful. However, it is reduced to a few examples of ecosystem dynamics. It would be useful to elaborate on climate interactions in the context of a land systems framework, or through the lens of land change science, which would focus on LCLUC-specific issues. This is also a place to discuss nature-based solutions or natural climate solution frameworks, offering insights on the value and characteristics of land-based adaptation and mitigation.

Key Message 6.3. Future Land-Use Options. It is important for the chapter authors to carefully discuss current trends and status of LCLUC; some studies suggest the rate of land conversion is diminishing and will continue to decrease into the future. The current data on land cover in the United States suggests that pasture is the largest category and urban is the lowest, yet the draft NCA5 report emphasizes urban development and barely discusses pasture. This chapter seems to suggest that developed land is the cover category with the greatest net change in area. However, because change can be an increase or a decrease in area, this is misleading because combined area changes in forest, agriculture, and pasture far exceed developed, as well as the net change, according to NCA4 and Auch et al. (2022) since 2016. Therefore, either something has changed recently or the draft NCA5 report is inconsistent with past assessments and recent literature. Moreover, there appears to be evidence that these vegetative cover classes also declined in *use*, which would be an important observation to explore and project into the future. Auch et al. (2022) notes that the percentage of land in CONUS undergoing cover change each year has been declining. The two most prominent patterns of land-cover change were natural resource cycles and increases in urban and built-up land. Natural resource cycles accounted for 80 percent of all annual gross change, with these processes mostly involving the loss and gain of tree cover through harvest, wildfire, other natural events, and its regrowth, as well as fluxes between cropland and grass/shrub. Gurgel et al. (2021) uses a multidimensional econometric model and suggest no major shifts in land-use change trajectories, with most future changes in agriculture, not developed land (urban). The emphasis on developed land conversion diminishes other land-use changes of importance, such as conversion of grasslands to croplands for biofuels (Lark et al., 2022).

Comments on Traceable Accounts

Traceable accounts are done well but lack citations in some places, except for Key Message 6.3. However, due to the lack of projections and forecasts on specific important climate change impacts related to LCLUC, the connection between the literature and the statements in the key messages is weak. The chapter does an adequate job using confidence and likelihood in

its key messages, but the statements are not adequately justified in the traceable accounts. Consideration of literature on land system drivers, such as economic or production factors, and how they are influenced by climate change should be added. Also, traceable accounts could be improved by organizing them by human system and natural system drivers and factors. In the context of this chapter, LCLUCs are largely driven by human decision making rather than natural events, which are better described in other chapters. However, some of these economic or production drivers may be influenced by natural factors and climate change. For example, the authors of this chapter have done an excellent job noting the importance of land-use choices and their constraints due to climate change. Thus, it would improve the traceable accounts if there were a clear distinction between the literature and science that supports the human drivers and the literature and science that supports the climate and natural systems drivers.

Comments on Graphics and Boxes

The graphics should be reconsidered. There are specific mentions of graphics issue above, but generally they do not capture the reader's attention, and some are confusing. Graphics could be better used to support boxes and/or specific examples. A good approach to graphics can be found in Chapter 5 (Land Cover and Land-Use Change) of NCA4.

Figures 6.1 and 6.2 should include Alaska and Hawai'i. The zoom-in boxes in Figure 6.2 are useful to show additional detail which would not be apparent in the national-scale maps. Chapter authors should consider adding additional inset boxes, and add some simple overlays, such as the Yellowstone National Park boundary, to help audiences relate to the content.

Comments on Equity and Justice

There is little discussion of the equity and justice dimensions of LCLUC, which should be improved because equity and justice implications are very important in the context of LCLUC. It might be useful for chapter authors to lay out how Key Messages 6.2 and 6.3 relate to equity and justice, particularly the way choices could be constrained, and ways to think about inclusion in the process of decision making under climate change and LCLUC influences.

The equity and justice framework could be broadly used to consider the distribution of benefits and harms, recognition, and participation. The chapter could consider the equity and justice framework historically; what drives LCLUC decision making by whom? For whom? How? This approach could be used to consider these factors relative to climate change. The authors already note well how climate change will constrain land-use decisions generally, and chapter authors could also explore land-use decision making in the equity and justice context. Multiple histories of social and spatial marginalization with impacts on present-day LCLUC include zoning decisions, investment/disinvestment, redlining and connection to present-day spatial distribution of grey and green infrastructure, and ecological fragmentation.

There are also potential issues related to mitigation and adaptation because land systems are likely to be significant parts of many policies and measures. Chapter authors should consider the distribution of benefits and harms in this context, as well as decision-making structures or frameworks that may increase or reduce vulnerability to climate impacts and land-use impacts.

The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible. Finally, specific gaps in

equity- and justice-related literature with respect to the chapter focus should be noted in the text or traceable accounts.

Comments on Data and Analyses

The analysis of data is fine, but there are few quantitative insights on how LCLUC and climate change could impact the economy. It would be useful to include a few examples. As noted above, it is important to make sure that the data on LCLUC are correct, consistent, and standardized, adhering to definitions and concisely stated in common units.

Comments on Literature Cited

The cited literature is good except in three areas: (1) concepts and findings from the land change science literature could be used more, especially as a way to frame the chapter in a broader LCLUC framework, which is a science area of its own; (2) the chapter could reference the current data on land cover and land-use areas and changes, some of which have been provided here; and (3) the drivers of LCLUC are perhaps distinct from drivers of ecosystem changes—they include economic and yield factors, for example. It would be an improvement to use this literature, especially for analyzing projections in Key Message 6.3. Some references could be updated with more recent literature.

Other Recommended Changes

There could be more emphasis on the connection between mitigation and adaptation and the importance of LCLUC. In addition, LCLUC is often referred to as the “other global change” and it will have its own impacts at the same time as climate change. This point is not well treated; the importance of LCLUC and its role as a mediator for climate change could be discussed more. Lastly, the chapter omits complex changes and impacts (e.g., degradation, fragmentation, regeneration in odd locations) in favor of simple changes and impacts (e.g., infrastructure).

CHAPTER 7: FORESTS

Summary

This is a generally strong chapter that reviews the important aspects of climate change impacts on forests in the United States, emphasizing its impact on creating new and complex changes to disturbance regimes, the potential for losing forests’ capacity to continue to provide abundant and important goods and services, and the challenges and prospects ahead for adaptation management of forests. These three elements form the basis for three important, logically framed and presented key messages. The chapter meets the requirements of Section 106 of the GCRA but could be more explicit in the evaluation of projections.

Climate change impacts are presented well in the context of current and potential adaptation responses, but more examination of mitigation could be added. Generally, the chapter captures the most salient new developments in scientific understanding, the evidence base, and

research gaps. However, at times, the text is too nuanced for the intended audiences, defined in Chapter 2 of this report. For example, the discussion of how climate change exacerbates existing disturbances, interactions between disturbance agents, and disturbance regimes could be bolstered with different examples. The writing is at an appropriate technical level but could benefit from more citations emphasizing the domestic forest research basis of the key messages and fewer citations from global-scale forest analyses, as well as adding clarity and specificity on the emissions and removals estimates, since forests are a significant sink.

The key messages are objective and include statements where there is strong and weak evidence or certainty. Key messages also acknowledge complexities in attributing impacts, for example, referencing the compounding influence of management and land-use change. Although there is an explanation given in the traceable accounts, both confidence and likelihood levels should be assigned to statements in the key messages, consistent with definitions presented in the Front Matter and used in other chapters.

The Committee commends the chapter authors for their use of cross-chapter references to other key messages. The treatment of equity and justice, however, is light, giving most attention to Indigenous communities. This discussion could be enhanced with examples of notable successes, for instance, with tribal communities' mitigation and adaptation examples that are well known in the literature and public record and discussed in other chapters. Finally, the importance of natural variability cannot be overstated when trying to evaluate climate change impacts and demonstrating the difference between climate change and natural variability; it would be useful to acknowledge these differences to provide more confidence in the chapter's key messages.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction is adequate but provides mostly background on the importance of forests. The addition of short text on how climate change impacts are affecting forests would provide essential context for the key messages and would balance the introduction with the rest of the chapter. The three key messages are logically ordered, so a few sentences in the introduction would provide readers with a chapter map (i.e., complex and changing disturbance regimes, resulting loss of value in goods and services, and adaptive and mitigative responses are under way but more will be needed) to provide relevant context. Whether here or later in the chapter, it may be useful to address the issue of the recent loss of forest stock and the associated risks of a declining carbon sink at a time when adaptation and mitigation measures need to enhance biological sinks, especially in forests. Additionally, introducing the importance of forests for overburdened communities would also be valuable in the introduction to help better integrate equity and justice principles throughout the chapter. Similarly, the introduction lists the goods and services that forests provide, including “spiritual renewal” but does not mention the Indigenous cultural values of forests. Although these cultural values are covered in Key Message 7.2, they are also important to integrate into the introduction.

Finally, more discussion of the role of natural variability in addition to climate change would benefit the chapter; to frame this discussion, the Committee suggests adding a sentence in

the introduction about how extreme events occur naturally and how climate change can change the frequency.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The three key messages presented in this chapter accurately reflect current understanding of impacts associated with climate change are logically connected and follow a good sequence. However, as presented, their titles are not effective. Each key message is well described by providing the reader with background on how forest ecosystems function and how changes could occur with climate change and the implications for forest structure and function, their provisions of ecosystem services, and management challenges. They are written well and presented objectively, considering areas of certainty and areas of uncertainty. The use of confidence rankings is adequately done, but the use of likelihood differs from the definition used in the report and by other chapters. This chapter is very similar to the chapter on Forests in NCA4—for example, the three key messages are the same and the emphasis on fire (severity and scale), extreme weather effects, carbon, and water are overlapping. This chapter should emphasize more the interaction of disturbance agents, which would be an important new element to present, but it would need additional detail and better examples in Key Message 7.1 (e.g., the example on bark beetles is good but that on ghost forests, which is more of a direct impact issue, is less useful). Continuing to update audiences on the impacts of the provision of goods and services is useful, but new evidence or examples would be more insightful than those presented. To this end, the declining carbon sink observation presented here is also perhaps new in Key Message 7.2, so that could be elaborated on.

The key messages, especially Key Message 7.1, focus on the interaction between agents of change. This focus is useful for demonstrating the complexity of system-wide impacts, but the Committee suggests that the chapter authors revise the text to be explicit about the interactions between agents. For example, to increase readability, it would be useful to better describe interactions of climate factors, such as temperature and drought, and interactions of ecosystem factors, such as pests and fire and include brief text that makes it clear how scientific evidence is distinguishing between the natural background variability and attribution to climate change.

Most of the text on risks and impacts is somewhat general. It would be useful to have a few specific quantitative forecasts of impacts or provide an update on the discussion of “future forests” from NCA4. The key messages focus on impacts from climate changes related to extreme events and impacts related to increased severity and frequency due to precipitation and temperature.

Lastly, the discussion of equity and justice should be bolstered. There is some discussion of Indigenous communities, but less on other aspects of diversity, including key issues such as access to forests benefits generally, and trees in urban areas. There are some good examples of mitigation and adaptation activities in tribal areas that could be discussed in detail, such as the Yurok tribal forest carbon credit projects in northern California, which are long-standing climate change mitigation and sustainable forest management examples that demonstrate the effectiveness of alternative models of natural resource management (Fleischman et al., 2021; Manning and Reed, 2019).

Comments on Specific Key Message Language

Key Message 7.1. Climate Change Affects Forest Change

Forest ecosystems support livelihoods, regulate climate, and maintain and protect biodiversity. Climate change is increasing the frequency, scale, and severity of some disturbances that drive forest change (*high confidence*). Continued warming and regional changes in precipitation are expected to amplify interactions among disturbance agents (*likely, high confidence*) and further alter forest ecosystem structure and function (*likely, high confidence*).

Suggested title: “Climate Change Is Now a Dominant Form of Human-Induced Disturbance to Forests That Exacerbates Existing Disturbances.”

This key message is well done, but there is some confusion in the title and the key message text with the use of “change” twice. The Committee suggests an alternative, formulated as a statement as shown above. This key message first introduces a few important disturbances affected by climate change, including increased fire severity, pests and insects, and disease. It then introduces factors that affect forest indirectly due to changes in climate factors such as drought, extreme weather, and others that exacerbate the disturbance impacts. For example, drought or warmer winters affect pests which causes increased disturbances. Thus, while this key message is very similar to the presentation in NCA4, it introduces or emphasizes new concerns about complexities introduced by disturbance interactions. As this point is important, the Committee suggests elevating it within the key message. Additionally, it could be strengthened by elaboration, more focused examples, and noting the importance of distinction from natural variability in the supporting text.

Including a point about direct and indirect influence of climate change means the text should clarify whether the supporting evidence points directly to climate change or to factors that are logically but perhaps not demonstrably linked to climate change. For instance, the sentence “Climate change is increasing the frequency, scale, and severity of some disturbances that drive forest change (*high confidence*)” is fine. However, it is unclear whether evidence exists, and confidence is high, that climate change has in fact, caused severity to increase and has resulted in some impact on forests. It is important to be concise and perhaps explain the evidence directly in the text supporting the key message or in the traceable accounts. Also, the use of the words “some disturbances” is vague, and the Committee suggests rephrasing or elaborating with examples.

Key Message 7.2. Climate Change Affects the Goods and Services Provided by Forests

Forests provide goods and services that enrich human lives and sustain life more broadly. Increasing temperatures, changing precipitation patterns, and altered disturbances are reducing the capacity of forest ecosystems to sequester and store carbon (*high confidence*), provide clean water and clean air (*high confidence*), produce timber and non-timber products (*high confidence*), and provide recreation (*medium confidence*), among other benefits. Future climate effects will interact with societal changes to determine the future capacity of forests to provide goods and services (*likely, high confidence*).

Suggested title: “Climate Change Alters and Diminishes the Goods and Services Provided by Forests.”

Unlike Key Message 7.1, this title is already an informative statement, but a slightly modified example has been provided.

Key Message 7.3. Adaptation Solutions

Climate change creates challenges for natural resource managers charged with preserving the function, health, and productivity of forest ecosystems (*high confidence*). Forest landowners and managers are preparing for climate change through the development of vulnerability assessments and adaptation plans (*high confidence*). Proactive adaptation of management strategies that create, maintain, and restore resilient forest ecosystems are critical to ensure continued and equitable provisioning of goods and services (*high confidence*).

Suggested title: “Forests Provide Significant Adaptation and Mitigation Opportunities, But Some Forests Are at Risk.”

Comments on Text Supporting the Key Messages

The supporting text for the key messages is strong but sometimes rather nuanced. Some of the ideas repeat NCA4, so emphasis should be placed on the new material and evidence, such as the interaction of disturbances and the shrinking carbon sink. However, when using estimates of emissions and removals, some standardization of data sources should be used, and where differences are necessary (e.g., in Key Message 7.2), they should be clearly described in the text supporting the key message or traceable accounts. The key messages would all benefit from more cogent examples. Similarly, the chapter is strong on presenting evidence of trends, but this should be followed by a brief statement about how a trend is directly attributed to climate change. Forecasts would be useful, as would some references to economic impacts in Key Message 7.2. The chapter overall is good at identifying cases where evidence is weak, but it should also clearly state what is known. Key Message 7.3 is good but heavily focused on adaptation and should also include a discussion of mitigation. To do that well, it would be important here and in other chapters to ensure that there is consistency in how emissions and removals are reported, and in the data source(s) used. In particular, the forest sink term is reported differently throughout the draft NCA5 report, not only in the magnitude but also in attribution (e.g., agricultural land abandonment is noted as a major sink in Chapter 11 (Agriculture, Food Systems, and Rural Communities) when it is not actually reported as such in EPA [2022]). In the draft NCA5 report, the emissions from harvested wood products (HWP) are reported with no reference nor explanation of how or why it appears to differ from EPA (2022) and Domke et al. (2021).

Key Message 7.1. Climate Change Affects Forest Change. In addition to the points mentioned above, it is noted that climate change would amplify the interactions of agents of disturbance but assumes the reader will know this is a negative influence. Forests are dynamic; they experience disturbances, but climate change will increase the frequency and severity of these agents. There will be interactions among them (e.g., drought, insects or pathogens, tree die off, hurricanes, land-use change, fire). The chapter points out that fire suppression and land-use change reduce the adaptive capacity of forests to climate change. The text discusses tree

mortality as an impact, but there are also more complicated and serious impacts on overall demography, especially the balance between mortality and recruitment, which itself is complicated by fecundity and migration dynamics.

Key Message 7.2. Climate Change Affects the Goods and Services Provided by Forests. This key message extends logically from Key Message 7.1 and aims to identify the important ways climate change reduces the current and future provisioning capacity of forests. Emphasis is given to carbon sequestration, non-timber products, biodiversity, heritage and cultural values, recreation, and water. These are important and could be strengthened by emphasizing economic impacts or cross-referencing other chapters. Estimates for future economic impact, including from HWPs, would engage readers. The key message is very similar to what was presented in NCA4. A new emphasis could be a focus on reductions in the current forest sink, which is important. Although this is in part attributed to land-use change, it would be useful to explicitly emphasize the link to climate change and supporting evidence.

As in other chapters, current estimates of emissions and removals of carbon and other GHGs is provided as an important consideration. However, the text supporting this key message is confusing regarding the source of data and how they are used. As discussed in Chapter 2 of this report, the Committee suggests using a standard source for the US GHG inventory (i.e., EPA, 2022). In doing so, this chapter should explain how the US Department of Agriculture (USDA) estimates may differ (i.e., how harvested wood products are computed as emissions and removals). The citation to Domke et al. (2022) does not exist in the references, and it is not possible to locate the citation nor a publication that can be used for Figure 7.8. The net sink term from this chapter and in this figure appear to contradict other estimates in other chapters. These estimates also appear to contradict EPA (2022), and the estimation method in this chapter appears to differ from EPA (2022); here, the net sink is diminished compared to EPA (2022) due to high emissions from HWPs that are not clearly reported in national inventory reports. The reader should be aware that a HWP pool has emissions and is only effective over the long term if the harvested wood is part of a rotation with regrowth. The citation to Johnston and Radeloff (2019) is not the best citation or should be clarified because it is a global analysis and does not consider the rotation issue in the same way as in the US inventory.

This key message does a good job of distinguishing between chronic and abrupt changes. Additionally, this key message is an adequate discussion of environmental justice and cultural issues, but it is somewhat narrow. The discussion could include success stories from Indigenous actions and management such as carbon management on tribal land (e.g., Yurok). There are no citations for the first sentence of each of the first three paragraphs of the supporting text for this key message (page 7-10, lines 17-27, and page 7-11, lines 1-7), making these sentences appear as assertions. The text would be more compelling with citations, and the Committee suggests rewriting assertions to avoid stand-alone text without citations.

Key Message 7.3. Adaptation Solutions. This key message is well done and backed by evidence and examples. It could be improved using better examples from an equity and justice perspective. As mentioned above, there are good examples from tribal management of carbon projects for both mitigation and adaptation. The focus is on adaptation solutions, but mitigation is also very important for forests. One of the most important messages relates to the already strong role forests play as carbon sinks, and this is currently at risk due to a decline in forest stock and productivity caused by climate change (e.g., fire) and land-use change (e.g., urban encroachment). This point and the loss of buffer against severe impacts of fire at the wildland-urban interface could be stated more strongly.

Comments on Traceable Accounts

The trend and current emissions and removals of GHGs have not been considered coherently in this chapter; placing more emphasis on mitigation versus adaptation could help. However, the estimates of carbon and CO₂-equivalent in this chapter are difficult to interpret; they appear to have inconsistencies with other chapters and within this chapter. This chapter suggests that the national net sink for carbon is ~402 Mt CO₂-equivalent in 2020. This is based on Net Ecosystem Carbon Balance in 2020, taking into consideration transfers and emissions from HWP. These estimates appear to differ from other chapters, from the incorrectly cited Domke et al. (2022) (which is perhaps Domke et al. [2021]) and EPA (2022). The traceable accounts section should either reconcile these apparent differences or clearly explain how the accounting is done.

Key Message 7.1. Climate Change Affects Forest Change. The evidence basis for forest disturbances attributed to climate change either directly or indirectly is lacking. These include changes in fire regimes (frequency, magnitude, severity), pests (e.g., bark beetles), forest health, and disease. The traceable accounts provide background evidence for climate change effects on fire regimes, and far less for other factors. Evidence directly showing the linkages from climate change to ecological factors to forest impacts is less clear and should be strengthened. The interpretation of the literature on page 7-8, lines 11-12 is incorrect: “western tree species are migrating poleward through seedling success (Sharma et al. 2021).” The analysis by Sharma et al. (2021) actually cautions that although a migration potential exists due to changing climate factors that influence seedling success, local terrain conditions actually constrain migration at the same time.” Specifically, the paper says: “Whereas fecundity may be primed to lead tree migration in the West, local climate complexity that comes with rugged relief affects how migration potential should be interpreted. The combination of dry climates and fast climate change in the intermountain West explains fecundity and recruitment vectors in Figure 3 E and F that point toward the cool, moist regional climates of the Northwest. However, for migration, these cool-moist conditions are locally found at higher elevations. The regional centroids average over this variation contributed by steep terrain.”

Additionally, natural variability is important, not only because natural ecosystems such as forests are dynamic and some of the adverse impacts of climate change are also naturally occurring, but also because in any observational sense the climate impact is buried in the “noise” of the natural dynamics and needs to be teased apart from it. This complexity makes it complicated to measure, assess, and attribute impacts to natural variability versus climate change. This complexity could be noted, with a rationale or examination of the evidence within an explanation of how the science can attribute climate change impacts. Clarifying these attributions is especially important for Key Message 7.1 since it focuses on the complexities added by multiple agents and stressors.

The discussion of gaps is very useful, but it may understate the current knowledge gaps. One reference worth citing and describing is the recent report by Novick et al. (2022), and overall, the discussion of gaps could be expanded with more citations. One area of concern not addressed in this section is the multiple, and perhaps confounding, influence on climate change from forest management and forest cover change. This is a consideration of the difference between radiative forcing due to GHGs and surface water and energy balance; in some cases, forest cover increases warming even while it sequesters carbon. The traceable account rightly acknowledges gaps in understanding related to hydrology.

Key Message 7.2. Climate Change Affects the Goods and Services Provided by Forests. This key message focuses on the importance of changes in US carbon sinks, forest products, ecological functions, cultural and heritage values, recreation, and water resources. As noted above, there should be a discussion on the data sources and use of data on emissions and removals. The new estimates on forests that appear in Figure 7.8 are neither referenced nor cited. Domke et al. (2022) is cited in the traceable accounts but not found as a reference; if this is a mistaken reference to Domke et al. (2021), then the citation in the traceable accounts is misplaced. Other than carbon sequestration and water, the main statements in the key message are associated with diminished goods and services, including changes in the range and abundance of species, heritage values, recreation, and health, but only supported by a few references to literature. This section of the traceable accounts could be bolstered.

Key Message 7.3. Adaptation Solutions. This key message focuses on adaptation. The review of evidence in the traceable account is not deep; it would be useful to know more about the review of evidence on the potential for success with assisted migration. The key message does not address mitigation, so there is no discussion of it in the traceable account.

Comments on Graphics and Boxes

There are many graphics and figures that were not available for the Committee to review, so evaluation here is limited. Key Message 7.1 would be improved if the figures and boxes directly expanded on the idea of interactions with and between agents of disturbance to highlight this aspect and advancements since NCA4. Table 1 from Key Message 7.3 has errors. Figure 7.7c attributes the decline in the US carbon sink to tree mortality but in other places and chapters, the reason is given as land-use change. The Committee has additional comments on individual graphics and boxes below.

Figure 7.1 is useful but needs an expanded caption and a citation. Additionally, it is not clear what the pink, white or grey colors are, and clarification would be useful.

Figure 7.3 is not shown but could be eliminated or replaced. It is indeed a good example of direct forest impact from climate change (SLR) but detracts attention from the point about the interaction of disturbances.

Figure 7.4 is not shown. It may be useful but possibly more relevant to NCA4 than here.

Figure 7.5 is somewhat general and might be replaced.

Figure 7.6 is not clear where it shows spruce beetle damage, and the box may serve the reader better.

Figure 7.8 should be better documented and explained. Abbreviations should be defined. It is unclear where these estimates are sourced, and how they are derived, compared to other sources such as EPA (2022).

Figure 7.10 is not useful on its own and does not show examples of adaptation practiced as referenced in the text.

Box 7.2 would be very useful if more details are included, and the numbers are verified.

There is an opportunity to create a box in Key Message 7.3 describing the Yurok tribal work in carbon management, sustainable forestry, and heritage values.

Table 7.1 is useful and would be improved with a box for Key Message 7.3.

Comments on Equity and Justice

Broadly, there should be more integration of equity and justice, including in the introduction. There are opportunities for positive stories of successful adaptation and mitigation, especially from tribal communities. There is adequate discussion of Indigenous communities, including traditions and governance issues, but this discussion could be bolstered with the inclusion of adaptation and mitigation examples of carbon management projects, such as the Yurok projects in California and the Great Lakes states. Additionally, different dimensions of equity (distribution of costs and benefits, recognition, procedural, intergenerational equity) as they relate to forests should be integrated where possible. Discussion of governance and access as well as supporting literature should be included. Urban heat islands and reforestation efforts, particularly in formerly redlined areas, can be discussed.

There is an emerging literature on urban forestry and environmental justice (Grant et al., 2022; Watkins and Gerrish, 2018), which could be referenced to review ways to remedy past inequities and create future benefits derived from new approaches to the management of urban tree systems (Nyelele and Kroll, 2020; Zhou et al., 2021).

The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible, to highlight the interconnectedness and complexity of these issues. Finally, specific gaps in equity- and justice-related literature with respect to the chapter focus should be noted in the text or traceable accounts.

Comments on Data and Analyses

Data analysis is generally well done, but there is little analysis for future projections, nor specific forecasts in terms of economic loss or cost of lost ecosystem services. The analysis of hardwood products and the US carbon sink should be clearly stated and described.

Comments on Literature Cited

Generally, the chapter cites appropriate literature, but the use of global literature can confuse the reader since the condition of US forests is vastly different than the global condition and trends (Auch et al., 2022; Kubiszewski et al., 2020). There are also more sources available on research gaps (e.g., Novick et al., 2022; Seddon et al., 2021) that would strengthen the chapter. In addition to citations provided to examples from Yurok, more references to Indigenous forest management and restoration could be explored, such as Reyes-García et al. (2019) and Long et al. (2020). The citation made in this chapter to Domke et al. (2022) is confusing—the Committee cannot find it referenced and does not readily appear in the literature when searched. If it is an update of Domke (2021), which is also cited in the chapter, it is an important reference given how it is used for evidence. Another issue with the literature cited is the lack of standard references for some important data, discussed above. For example, the chapter should use a standard GHG emissions reference or source, such as EPA (2022). This could be augmented with any critical USDA data on GHG emissions, when differences are explicitly stated and reconciled. Similarly, there should be a standard and common reference or source for land-use change data and statistics.

Other Recommended Changes

It may be worth explaining briefly in the introduction why forested ecosystems have their own chapter (in addition to Chapter 8 [Ecosystems, Ecosystem Services, and Biodiversity] that covers all types of ecosystems). Is it their extent, the economic value of goods (provisioning), their importance for regulating services, carbon sequestration? These are all implied in the introductory material but should be explicitly stated. No other terrestrial ecosystem (e.g., rangelands) is the sole focus of a single chapter.

CHAPTER 8: ECOSYSTEMS, ECOSYSTEM SERVICES, AND BIODIVERSITY**Summary**

Chapter 8 (Ecosystems, Ecosystem Services, and Biodiversity) analyzes the effects of climate change along with other stressors (i.e., other global change drivers) on the natural environment and biological diversity by integrating current evidence about ongoing trends and projected trends for the future. It also examines trends in the knock-on effects of ecosystem change on agriculture, water resources, and human health and well-being (“ecosystem services”). The key messages encompass the key impacts of global change on ecosystems and reflect the current understanding that climate change interacts with other global change drivers to affect ecosystems. Emerging issues identified included abrupt changes triggered by extreme (weather) events. Also novel, the chapter provided a framework for adaptive ecosystem management—Resist-Adapt-Direct. Examples of operational adaptation (e.g., restoration, habitat protection, assisted migration, intensive management) were included. This chapter examines natural ecosystems and does not go into detail on managed ecosystems such as agroecosystems or working forests. It would be useful to provide this perspective to the reader as well as references to other chapters that discuss these issues. The chapter could explicitly note that it does address land-use and other human impacts, which provides useful and important context.

Key findings are generally stated at an appropriate technical level (see specific suggestions for plainer language and avoiding jargon) and are supported by evidence that is documented in a credible way (see specific suggestions for providing concrete examples). The chapter includes many abstract or general mentions of adaptation, and more specific examples would enhance the narrative. While the chapter broadly meets the requirements of Section 106 of the GCRA, it would also be more compelling if the introduction began with a stronger message reminding the reader that ecosystems are central to everything humans (and all life forms) do, make, breathe, and eat—reliance that is invisible or abstract to many people in their day-to-day lives.

Chapter 1 (Overview) in the draft NCA5 report emphasizes many issues in Chapter 8 (Ecosystems, Ecosystem Services, and Biodiversity) (e.g., climate change harms ecosystems and reduces ecosystem services; coral reefs and rainforests are particularly vulnerable to extinctions; without emissions reduction ecosystem change may be irreversible; adaptation options are limited but restoration could be targeted). However, Chapter 1 (Overview) could emphasize more that climate change interacts with other stressors that affect ecosystems (e.g., human activities including land-use, pollution, overharvesting, and novel pests and pathogens), as is emphasized in this chapter. Chapter 1 (Overview) uses the term “compound” in several

instances; there could be more consistency between this chapter and Chapter 1 (Overview) on the concept and terminology for multiple stressors, and compound events or effects.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction explains that humans depend on ecosystems and biodiversity (ecosystem services), and outlines, with examples, how climate change damages and changes ecosystems and how those impacts degrade ecosystem services. The introduction also outlines risks to ecosystems and lists adaptation strategies. However, the chapter needs a stronger lead conveying with urgency that ecosystems are central to the fundamentals of living. The introduction should emphasize how human actions are threatening the Earth system including the biosphere; the extinction event we are causing will be visible in the fossil record for as long as Earth persists. Context should be provided to explain how species make up ecosystems that provide air, water, food, materials, and energy. Through kinship and reciprocity, ecosystems also are the foundation of human spiritual and mental health. These “fundamentals” about ecosystems as life support, are given in the first few paragraphs but could be strengthened through rewording.

This framing could include an even more basic reminder of important first principles—key concepts such as “ecosystems,” “biodiversity,” and “adaptation strategies” (as they apply to ecosystems) should be briefly defined without jargon in the introduction. For example, the reader should be reminded that ecosystems consist of plants and animals, and plants not only provide food at the base of food webs, but they also fix carbon and release oxygen (making life on Earth possible for air-breathing animals). The introduction should mention that the biosphere is important to the global carbon, nitrogen, and other biogeochemical cycles and how the biosphere is already buffering against climate change through sinks and feedbacks. This basic description of what ecosystems are and do is implied in the chapter where, for example, carbon sequestration in ecosystems is mentioned in several places. It would, however, improve the impact of the chapter to briefly introduce the chapter’s “main character” (ecosystems) in this way. Some text could be moved up to the introduction from later in the chapter (e.g., page 8-7, lines 16-18) so that the word count would not increase with these additions. In addition to the key concepts already mentioned, “ecosystem services” should be defined in the introduction before it appears elsewhere in the chapter (e.g., in Figure 8.1).

Comments on Key Messages, Supporting Information, and Traceable Accounts

Overall, the key messages encompass the key impacts of climate change on ecosystems and reflect current understanding that climate change interacts with other global change drivers in affecting ecosystems. The key message titles should be written as short, informative statements, rather than few-word headings.

Comments on Specific Key Message Language

Key Message 8.1. Ecosystem Transformation

Climate change, together with other stressors, is driving transformational changes in ecosystems (*very likely, high confidence*), which presents increasingly serious challenges for natural resource management (*very likely, high confidence*). Many types of extreme events are expected to increase in frequency and severity and potentially trigger abrupt ecosystem changes (*medium confidence*). Adaptive management to prepare for, respond to, and lessen potential impacts can be advanced by decision frameworks that identify key risks and by monitoring for early warning indicators (*medium confidence*).

Suggested title: “Ecosystems Are Being Degraded and Irreversibly Altered by Climate Change.”

This key message appropriately emphasizes the interaction of climate change and other stressors, as well as current understanding of abrupt and irreversible change. The key message manages to avoid jargon (e.g., the key message uses the term “tipping point” but also defines what it means). While the key message is somewhat abstract, examples are given in the subsequent text. However, “transformation” is not consistent with terminology in the current literature: degradation and collapse (Keith et al., 2015, 2022).

Additionally, the key message could have been written in even plainer language. Here is an example of paraphrasing (we have not included the certainty language in this example for simplicity):

Climate change along with other human-caused stressors like habitat loss and pollution, is completely transforming (degrading) some ecosystems (transformations that may not be reversible—ecosystem collapse) and increasing extreme weather events like hurricanes and marine heat waves are likely to trigger abrupt change. Examples of ecosystems on or over the brink of collapse are coral reefs and Arctic tundra. Ecosystems should therefore be monitored to look for signs of change and managed adaptively with an eye toward the future.

Key Message 8.2. Species Changes and Biodiversity Loss

The interaction of climate change with other stressors is causing biodiversity loss, changes in species distribution and phenology, and increasing impacts from invasives and diseases, all of which have economic and social consequences (*very likely, high confidence*). Future responses of species and populations will depend on the magnitude and timing of changes, coupled with differential sensitivity of organisms, with heightened extinction risks for some (*very likely, high confidence*). Identification of risks and prioritization of species and locations for protection will improve options for management (*very likely, medium confidence*).

Suggested title: “Climate Change Displaces Species and Reduces Biodiversity.”

The key message identifies the links between ecosystems (made up of species and their environment) and things people care about (security, livelihoods, and treasured aspects of nature). The key message could be paraphrased with plainer language (we have not included the certainty language in this example):

Climate change together with other stressors such as land-use and pollution are affecting populations of organisms, sometimes with compounding effects, leading to changes in phenology (e.g., seasonal timing of flowering), changing distributions and species loss, and increasing impacts of pests and diseases; these changes have economic and social impacts. It is important to identify risks and prioritize species and areas that are at the greatest risk for protection, management, and restoration (coral reefs, and insect pollinators are examples).

Comments on Text Supporting the Key Messages

Key Message 8.1. Ecosystem Transformation. In the text supporting this key message there are opportunities to add some specifics to the examples given. For example, the text could explain how extensive some of these “abrupt and irreversible changes” are in the tundra, coral reefs, and sagebrush rangelands shown in Figure 8.6, and explain the implications (e.g., loss of critical habitat for endangered species along with rangeland livestock production, magnitude of carbon that could be released from permafrost, numbers of unique species lost from US tropical forests as a proportion of all US species). There are many good examples given on invasive species risk (page 8-22), but the example of woody encroachment in grasslands is also a widespread large-scale ecosystem transformation in drylands that should be noted somewhere. Furthermore, it could be noted if in some cases, species invasions are driven directly by increased atmospheric CO₂ concentration, rather than the climate changes caused by GHG emissions.

Key Message 8.2. Species Change and Biodiversity Loss. In the text supporting this key message, abundant evidence for current trends and future risks is given, emphasizing crop pollination, disease threats to humans and wildlife, and invasive species. Examples are also given of adaptive management. More emphasis could be placed on diseases and pests affecting plants—bark beetles are mentioned, but little else—although this could also be placed in Chapter 7 (Forests) or some regional chapters where forests are important, and those chapters could be cross-referenced in Chapter 8 (Ecosystems, Ecosystem Services, and Biodiversity).

It is worth emphasizing even more pointedly that the greatest human driver of terrestrial biodiversity loss is, and has been, habitat loss due to land-use. Climate change and other stressors layer on top of land-use changes with the compounding effects mentioned in the chapter. Species cannot easily “shift their locations” as the climate shifts if intervening places are modified and, therefore, inhospitable to movement, and this should be noted in the text.

Key Message 8.3. Ecosystem Services Risks and Opportunities. In the text supporting this key message, it would be useful to clarify, when nature-based solutions (NBSs) are discussed (page 8-27), that those “solutions” mainly consist of ecological restoration or habitat and species conservation (as is clear in Figure 8.19), which is why there are virtually always “biodiversity” co-benefits. This would better tie the new, but now widely used, concepts of NBSs (focusing on biodiversity) and natural climate solutions (NCSs, focused on climate impacts) to more traditional concepts in ecosystem management.

Moreover, this key message focuses on NBSs, but leaves agriculture out of NBSs for climate mitigation (Figure 8.19), whereas IPCC would include agroecosystems in NBSs for carbon sequestration. The concept NBSs comes from the biological conservation literature and is related more broadly to sustainability, while the NCS concept comes out of the climate community. In fact, Figure 8.19 is adapted from a paper that has “natural climate solutions” in

the title. It is acceptable if the authors want to delimit this chapter to natural ecosystems and not agroecosystems, but on the other hand, “cover cropping” is mentioned as a NBS in Figure 8.18. The chapter should in any case cite other chapters (e.g., Chapter 11 [Agriculture, Food Systems, and Rural Communities], Chapter 6 [Land Cover and Land-Use Change]) that discuss agroecosystem management for climate change (and more broadly global change) mitigation.

Comments on Traceable Accounts

The chapter authors describe the process of developing this chapter with its emphasis on new literature since NCA4. In addition to a diverse group of authors, there were ten technical contributors to this chapter. The traceable accounts section effectively describes the evidence base and uncertainties for each key message.

The traceable account for Key Message 8.1 should include the need for adaptive ecological management to consider power and social equity issues specifically to lead to equitable solutions (page 8-31, line 34).

In the traceable account for Key Message 8.2, the ability of climate refugia to reduce extinction risk should be mentioned as an uncertainty given that those areas, too, are at risk under some scenarios (page 8-33, line 2). The traceable accounts section for Key Message 8.2 also includes the potential for human assistance to species migration as an area for future research. In fact, there has been research published on the potential of assisted migration to protect biodiversity under climate change scenarios (e.g., Bonebrake et al., 2014; Etterson et al., 2020). Perhaps the statement on the research gap should be revised to narrowly focused on the unanswered research question.

Comments on Graphics

In general, attention is needed to the figures and tables in this chapter to effectively communicate their messages.

The map in Figure 8.2 is nice way to include all geographic domains included in the draft NCA5 report, but there should be lines around the different geographic parts to show that they are all different maps/scales. The symbols are a good way to communicate change in each region, but they are too small and there is also no key for the icons. The Committee appreciates the inclusion of the USAPI in the map. In the table part of this figure, it would be useful to include a reference for each example and the caption should describe how the examples for each region were selected. In the fourth column for the Midwest, it is not clear that the ecosystem service change is for “loss of lake ice.” Similarly, for “pollen,” the ecosystem service change should be stated explicitly.

In Figure 8.3, some entries in the table portion of this figure are confusing. For example, “plants” in row 2 should be “crops.” Moreover, not all the ecosystem services in column 3 are clear—specifically, it is not clear how the phenomenon listed relates to an ecosystem (dis)service (e.g., “pollen,” “loss of lake ice”). Furthermore, this figure shows global, rather than United States risks (the source is from the IPCC). The caption should explain that it is based on global data.

Figure 8.4 is a useful figure on climate change effects on watersheds, but it is referenced in the chapter to illustrate the idea of occasional extreme events amplifying the negative effects of gradual change, with no mention of watersheds. The figure title and caption should be

modified to make this link clear. The figure also needs to be modified with some horizontal arrows if it is meant to illustrate amplifying negative effects.

Figure 8.6 is a better illustration than Figure 8.4 of occasional extreme events amplifying negative effects of gradual change (i.e., hotter, longer growing seasons, invasive grasses) combined with extreme events (i.e., novel wildfire promoted by invasive grasses in an ecosystem that is not fire adapted) leading to large-scale ecosystem degradation or collapse and loss of ecosystem services. Perhaps Figure 8.4 is unnecessary.

Figure 8.8 is a nice way to show all geographic domains in the NCA5, and it would be helpful if a similar map format was used throughout the report. Lines for Canada and Mexico are attached to the lower-48 states, but not Alaska.

Figure 8.11 should add lines around Alaska and Hawai‘i to show they are different maps, scales, and locations.

Figure 8.13 is a nice summary of a lot of information, although the caption could state more directly what is shown in the figure: it is not just a (random) “varied” response across species, but that in this case managed, wide-ranging non-native species are expanding while native species with narrowed ranges are declining.

In Figure 8.18, instead of “cover cropping,” the phrase “cover cropping and other soil conservation measures” should be used to encompass practices beyond cover cropping.

It is useful to have an illustration in Figure 8.19 showing the climate mitigation potential of NBSs. It is unfortunate that the co-benefits appear as lines and therefore relatively “small” compared to the quantitative carbon estimates shown as bars on the right, but there may be no better way to convey this information.

Table 8.2 is somewhat unsatisfying because while it does give examples of ecosystem services and their indicators, more details in the column on trends would be informative (i.e., time frame and region[s] where a trend had been observed or projected).

Comments on Equity and Justice

The chapter addressed equity and justice issues in the context of unequal access to nature and ecosystem services and is a focus of Key Message 8.3. Pages 8-25 and 8-26 are explicit about communities of color having less access to ecosystem services, and that housing segregation has created inequitable distributions of ecosystem services, specifically, access to urban green spaces that meliorate air quality and heat. These specific and explicit examples of who is harmed, why, and what ecosystem services they lose are very useful.

In contrast, on page 8-27, lines 10-12, the reference to environmental justice “problems” is vague and could be improved by being more specific.

Examples could be added of traditional (Indigenous) ecosystem management and restoration practices that support both cultural and spiritual relationships with nature and an equitable climate transition, for example, by cross-referencing other chapters and citing additional literature (e.g., Chapter 7 [Forests], Chapter 16 [Tribes and Indigenous Peoples]; Long et al., 2020; Reyes-García et al., 2019).

Additionally, equity and justice concerns in natural resource management and conservation are increasingly recognized in mainstream natural resource management policy and practice. Concerns and issues should be identified, especially around equitable benefit sharing. This chapter should also mention the Reducing Emissions from Deforestation and Forest Degradation framework and protected areas for biodiversity conservation.

Comments on Literature Cited

The references are generally appropriate and represent the best recent literature on global change and ecosystems. The authors might consider citing Law et al. (2021) and/or Law et al. (2022) for Key Message 8.3.

Other Recommended Changes

It is noted (page 8-34, lines 29-30, under Key Message 8.3) that CO₂ fertilization affects ecosystem productivity and carbon cycling (and ecosystem services that result from those processes), but generally the chapter focuses on climate change effects on temperature, water balance, etc. The direct effects of increased CO₂ concentrations could be called out specifically and distinguished from increasing temperature effects given their important role as a driver of ocean acidification and resulting profound changes in marine ecosystems. This could be spelled out briefly in the introduction, perhaps with citation to other chapters that may talk more about CO₂ fertilization (e.g., Chapters 3 [Earth System Processes], 10 [Oceans and Marine Resources]).

In the section “Disease Risks” under Key Message 8.2 (page 8-20), in the context of increasing risk of human and wildlife disease, it may be relevant to mention the One Health framework, mentioned in other chapters (e.g., Chapter 23 [US Caribbean]). It may be more familiar to human health experts than ecosystem scientists which may be why it is not mentioned here. This is a question for the chapter authors to consider, not necessarily a recommendation.

In the “Implications for Management” subsection (page 8-23), given the importance of this section, it would be nice to have a table or map showing more examples (by region) of climate change adaptation actions on behalf of species beyond the two mentioned in the text. This is not essential but would be informative, and perhaps there would be room for it if Table 8.1 were condensed or reformatted to be smaller.

CHAPTER 9: COASTAL EFFECTS**Summary**

Chapter 9 (Coastal Effects) is written at an appropriate technical level, provides a useful summary of coastal adaptation strategies, and effectively highlights issues of equity and justice—including the disproportionate impact of coastal change on under-resourced communities. However, the chapter fails to meet the third requirement of Section 106 of the GCRA, which states that the assessment should analyze and project major trends. Specifically, this chapter does not address regional sea-level trends and associated impacts across the United States, nor does it provide relevant attribution information and citations highlighting the relative roles of natural variability versus climate change in observed and projected trends. The lack of regional information is problematic because the target audiences of NCA5 is broadly defined as “decision makers,” and it should be made clear that decision makers should not base decisions on continental US averages. There is also a lack of emphasis on low-likelihood, high-impact outcomes related to deep uncertainty and the evolving scientific understanding of instabilities and tipping points in ice-mass loss from West Antarctica, which should be considered by

decision makers with proper context. Finally, the chapter bases many of its conclusions (especially for Key Message 9.1) on the Interagency Task Force (ITF) SLR scenarios, which is not problematic in itself, but issues arise due to differences between the ITF framework used for sea-level and the IPCC framework used for all other climate indicators across the draft NCA5 report. As a result, the application of the draft NCA5 report likelihood language regarding is inconsistently applied, and more effort is needed to make the discussion of sea-level projections in this chapter consistent with the treatment of other climate indicators discussed elsewhere.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The chapter introduction offers reasonable context, but the first paragraph should end with a statement communicating that coastal trends and impacts are highly localized and that interpretation of observed and projected trends should include consideration of regional and local differences.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The key messages reflect basic understanding of nationwide trends and impacts but lack relevant regional and local information, as well as nuanced discussion of the relative roles of natural variability and climate change in observations and projections. The key messages also lack sufficient support for likelihood statements in some cases. The discussion below expands on gaps that span multiple key messages, followed by comments specific to existing content in individual key messages. Additionally, the titles of the key messages should be rephrased to be short, informative statements, consistent with guidance in Chapter 2 of this report.

Regional Differences and Natural Variability

The lack of information regarding regional variations in coastal trends and impacts, and the lack of context in attribution of regional differences to natural variability and climate change is a critical gap in Chapter 9 (Coastal Effects) that should be communicated to decision makers (i.e., the target audiences as defined in Chapter 2 of this report). Presently, the chapter mentions regional differences in trends only once in a general statement on page 9-4, line 3, which is not sufficient, because acknowledging and utilizing regional and local information is essential for accurate science-based decision making and cost-effective adaptation measures. A key directive given to NCA5 authors is that the assessment should be relevant for decision makers, but, as this chapter is currently written, the lack of regional and local information (or even acknowledgment of its importance and where to find it) severely limits the utility of the chapter in the applied realm.

An example of this gap is the lack of any mention that the rate of SLR along the US west coast has been suppressed over the past 30 years by natural fluctuations in the Pacific climate, which is clearly demonstrated by Figure 2.5 in Chapter 2 (Climate Trends) yet not referenced at all by Chapter 9 (Coastal Effects). The spatial variability in sea-level trends is a critical context for practitioners in west coast coastal communities, who may wonder (or need to communicate)

why their coastlines have not experienced the sorts of regular impacts discussed as nationwide trends in Chapter 9 (Coastal Effects). It is equally essential to communicate that the suppression of SLR along the US west coast is associated with the natural climate variability that is expected to produce the opposite effect during future periods leading to enhanced rates of SLR and associated impacts relative to the global and US averages. There is a significant body of literature that discusses the suppression of SLR along the US west coast due to Pacific climate and its potential to produce enhanced trends during future decades (see any number of papers from Miller, Hamlington, Merrifield, Thompson, and others).

At a minimum, this chapter should point to the map of sea-level trends from satellite altimetry over the past 30 years in Chapter 2 (Climate Trends) and note the regional differences as context for the nationwide results presented here. In addition, the Committee strongly suggests that a map of future SLR across the United States and its territories be added to demonstrate how SLR is expected to vary spatially in the future. There is additional helpful discussion in the text of Chapter 2 (Climate Trends) that could be referenced as well (see page 2-13, lines 16-17). Chapter 3 (Earth System Processes) also includes relevant information on the relationship between sea-level and natural variability (see page 3-27) that could be leveraged to support discussion of the idea and its implications for decision making and adaptation without a significant impact on the word count. In general, this chapter provides few cross-references to other physical science chapters with relevant information that could be leveraged in the coastal context to provide nuance and utility at local to regional scales.

High-Consequence, Low-Likelihood Outcomes

Chapter 9 (Coastal Effects) lacks discussion of high-consequence, low-likelihood outcomes. The possibility of such outcomes is mentioned once on page 9-4, lines 17-18, where the authors state that more than 2 meters of SLR by 2100 is possible if emissions go undeterred. This statement needs to be explicitly connected to the ITF SLR scenarios that correspond to physically plausible, high-impact outcomes (Intermediate High and High) to provide context for the high-end scenarios and connect them to use cases in supporting text for Key Message 9.3 (e.g., critical infrastructure with long design lifetimes). As a corollary, it should also be mentioned that these high-end scenarios—while physically plausible—are either low probability (*very unlikely*) or of unknown likelihood. The fact that they are low or unknown probability does not make them unimportant, as our understanding of the processes that could lead to rapid ice loss (in the West Antarctic in particular) is still evolving. The authors should incorporate the growing literature surrounding rapid ice sheet collapse in the West Antarctic (there are many papers since NCA4 to draw upon) and inform the reader about these low-likelihood, high-impact possibilities, which directly addresses the risk-based approach adopted by the draft NCA5 report.

Overlap Between Key Message 9.1 and Key Message 9.2

There is substantial overlap between Key Message 9.1 and Key Message 9.2, and the ideas covered by each key message should be more carefully organized to make Key Message 9.1 and Key Message 9.2 distinct and independently useful. Otherwise, there is no need for two separate key messages. Key Message 9.1 focuses on coastal hazards and states that ongoing SLR “will cause significant disruption to coastal residents, including damage to livelihoods, economies, infrastructure (e.g., roads, utilities, wastewater facilities), and ecosystems (*likely*,

high confidence)." Key Message 9.2 focuses on people and ecosystems and states "the combination of reduced ecosystem services and damage to the built environment from exacerbated coastal hazards will increasingly burden communities, industries, and cultures, degrading the quality of life in the coastal zone (*very likely, high confidence*)." These two statements are largely synonymous.

Examining the supporting text for Key Message 9.1, the focus is primarily on (1) the physical impact of SLR on coastal groundwater and the height, extent, and duration of flooding; and (2) the physical impact of rising sea levels coupled with extreme wave and storm events. Thus, the Committee suggests that Key Message 9.1 focus more narrowly on changes to the physical environment, with content related to human systems and ecosystems (i.e., page 9-4, lines 30-34; page 9-5, lines 10-12) moved to supporting content for Key Message 9.2. Such a reorganization would then allow the overlapping statement in Key Message 9.1 (page 9-3, lines 33-35) to be removed. The Committee also suggests that the word "hazards" be removed from Key Message 9.1, because it implies impacts to people and ecosystems, which is the focus of Key Message 9.2. A more appropriate title given the focus on SLR and the physical environment would be "Sea-Level Rise Is Altering the Coastal Zone," which is more independent from the title of Key Message 9.2.

Comments Specific to Individual Key Messages

Key Message 9.1. Coastal Hazards Are Increasing Rapidly

The severity and risks of coastal hazards across the Nation are increasing rapidly (*very likely, high confidence*), driven by accelerating sea-level rise and changing storm patterns, resulting in increased flooding, erosion, and rising groundwater tables. Over the next years, sea-level rise along the majority of US coasts is expected to be as much or greater than the observed rise in sea-level over the last 100 years (*likely, high confidence*) and will cause significant disruption to coastal residents, including damage to livelihoods, economies, infrastructure (e.g., roads, utilities, wastewater facilities), and ecosystems (*likely, high confidence*). Accounting for mounting coastal and compound hazards could inform meaningful actions to address the cascading impacts of climate change.

The chapter authors should make clear what is meant by "rapidly" in the key message title or remove this subjective word. A similar statement is made in the title for Key Message 9.2 but without the word "rapidly." Does this mean coastal hazards are increasing more rapidly than impacts to people and ecosystems? If not, remove the word "rapidly." If so, justification should be added to the traceable accounts to define the difference between rapid change and slow change.

Key Message 9.2. Coastal Impacts on People and Ecosystems Are Increasing

Climate change is already affecting the resilience of coastal ecosystems and communities (*very likely, high confidence*). Climate change and human modifications to coastal landscapes, such as seawalls, levees, and urban development, are limiting the capacity of coastal ecosystems to adapt naturally and are compounding the loss of coastal ecosystem services (*very likely, high confidence*). Without proactive strategies, the combination of reduced ecosystem services and damage to the built environment from exacerbated

coastal hazards will increasingly burden communities, industries, and cultures, degrading the quality of life in the coastal zone (*very likely, high confidence*).

Key Message 9.2 is well stated, but the overlap with Key Message 9.1 needs to be addressed as discussed above.

Key Message 9.3. Transformative Adaptation for Coastal Communities

Marginalized coastal communities are disproportionately vulnerable to the impacts of climate change and have limited resources for adaptation (*high confidence*). Maintaining cultural and economic connections within coastal communities will require transformative adaptation that addresses the interconnection between ecosystems, communities, and governance (*high confidence*). Transformative adaptation, including incremental adaptations, community co-development of adaptation strategies, nature-based solutions, and managed retreat, can equitably respond to coastal climate change impacts (*high confidence*).

Suggested title: “Transformative Adaptation Can Help Coastal Communities to Respond to Climate Change Impacts.”

The key message title should be rewritten to be a short, informative statement, consistent with the recommendation in Chapter 2 of this report. Otherwise, Key Message 9.3 is well-stated, but authors may consider replacing the term “managed retreat” in the third sentence with “community-led relocation.”

Comments on Text Supporting Key Messages

Key Message 9.1. Coastal Hazards Are Increasing Rapidly. More detail is needed within the body of text supporting Key Message 9.1 regarding how likelihood statements are connected to amounts of SLR along the CONUS coast (page 9-4, lines 13-22). For example, how is the likelihood evaluated in the statement on page 9-4, lines 13-15? If this is based on the ITF SLR scenarios (Sweet et al., 2022), then it seems this statement assumes CONUS SLR will be greater than or equal to the ITF Intermediate Low Scenario. If so, this should be stated. It should also be stated in the traceable accounts how probability of SLR being greater than or equal to the ITF Intermediate Low Scenario is calculated. Why is this statement *very likely* rather than *likely* or *virtually certain*? Presumably, this is done by comparing to the ensemble-based projections from the IPCC, but this process needs to be outlined in the traceable accounts. Do the authors base this likelihood on specific SSPs? Or degrees of warming by 2100? More explanation and detail are needed. In general, it would be preferable to base likelihood statements regarding amounts of SLR on ensemble-based IPCC projections, which can be more readily discussed using the draft NCA5 report language for both likelihood and emissions scenarios. The discrete ITF scenarios provide useful decision-relevant timelines but are not well suited for making likelihood statements.

The handling of SLR projections is inconsistent across the draft NCA5 report (see Chapter 2 of this report). The regional chapters, for example, handle SLR projections differently, with some using ITF only (e.g., Chapter 22 [Southeast]), others using IPCC only (e.g., Chapter 23 [US Caribbean]), and still others attempting to relate the two but doing so incorrectly (e.g., Chapter 28 [Southwest], Chapter 30 [Hawai‘i and US-Affiliated Pacific Islands]). Chapter 9

(Coastal Effects) is the logical place for the connection between the IPCC and ITF SLR projections to be made clear. In this vein, the Committee suggests that the ITF scenarios be explicitly discussed in the context of the IPCC scenarios and that IPCC scenarios be added to Figure 9.1 to demonstrate (a) that the IPCC and ITF SLR projections are distinct, and (b) how the two sources of information compare to each other. Figure 12.4 in NCA4 provides an example for how to present this information on a single graph.

Describing the differences and connections between the ITF and IPCC projection frameworks is important because the framings for the IPCC projections and the ITF scenarios are designed for distinct purposes. One provides a range of possible SLR amounts; the other provides distinct decision-relevant timelines. In addition, it is intended that decision makers will use NCA5 to evaluate trends and risk across climate sectors and indicators. The draft NCA5 report prescribes language for likelihood and emissions (see Front Matter) to provide consistency, which is broken by the emphasis on a set of discrete scenarios that are not only not well suited for likelihood assessment but that also have names that overlap with draft NCA5 report confidence/likelihood language for emissions scenarios (Front Matter, Table 3). For example, if a decision maker wishes to evaluate how both precipitation and sea-level will change in their location under an Intermediate scenario, then for precipitation, they would be pointed to SSP2-4.5 (per Front Matter, Table 3). For SLR, however, the same decision maker would likely focus on the ITF Intermediate SLR Scenario due to the overlapping naming conventions, which according to the ITF report (Sweet et al., 2022) is roughly the 50th percentile of the Very High (SSP5-8.5) Emissions Scenario including Low Confidence Processes. Despite both being named “Intermediate,” these represent two very different emissions pathways with very different outcomes and levels of likelihood if evaluated on a consistent basis. The unfortunate overlap in the names of SLR and emissions scenarios could lead to decision makers incorrectly weighting the risk of impacts due to SLR relative to other climate variables (such as precipitation in the example above).

The Committee recognizes that renaming the ITF SLR scenarios is not a viable solution given their wide adoption in practice, but the authors can use Chapter 9 (Coastal Effects) to clearly explain the relationships and differences between the ITF and IPCC emissions scenarios to prevent misunderstanding and misuse of the scenarios. The Committee also recognizes that there is a description of the ITF SLR Scenarios in Appendix 3 (Scenarios and Datasets), but not only is the description of the scenarios in the appendix inadequate, but it is also unlikely to be viewed by many readers. Given the apparent confusion that exists between authors across the draft NCA5 report in navigating the relationship between IPCC scenarios and ITF SLR scenarios, the Committee suggests that this information not be completely relegated to an appendix. As noted above, multiple regional chapters attempt to link ITF SLR scenarios to IPCC emissions scenarios but do so incorrectly. Thus, direct and accessible clarification is needed to assist decision makers in making accurate, well-founded assessments.

Finally, the low-likelihood, high-impact ITF SLR scenarios should be explicitly connected to the IPCC Very-High Emissions scenario (SSP5-8.5) with the low-confidence processes (e.g., marine ice-cliff instability) included. This allows the low-likelihood, high-impact scenarios to be mapped onto the NCA5 confidence/likelihood language for likelihood and allows readers to evaluate the SLR scenarios in conjunction with low-likelihood, high-impact outcomes for other climate indicators.

Key Message 9.2. Coastal Impacts on People and Ecosystems Are Increasing.

Supporting content for Key Message 9.2 is well written and includes a balanced approach that

includes broad themes and local examples. The Committee suggests the authors consider two additional items that were not covered in NCA4.

First, one of the greatest potential impacts of SLR on human systems in the United States is the disruption of the Sacramento-San Joaquin Delta. This delta sits about 50 miles inland, but the entire system is at or below sea-level and protected by 100-year-old levees that come within inches (literally) of overtopping during present-day (e.g., 2017) riverine flood events. With another foot or more of SLR, this critical delta will be flooded with seawater (some estimates are a 60% chance this century), and water supply conveyances from northern to southern California could be interrupted for as much as 18 months, devastating trillions of dollars of the economy and more than 20 million people. This is a local example, but it is one of high impact that has not been mentioned in previous reports and highlights acute risks from SLR interacting with aging critical infrastructures.

Second, the Committee suggests the chapter authors mention the interconnectedness of adaptation efforts that may deflect impacts from one community onto another. A recent study (Wang et al., 2018) used hydraulic modeling to investigate what happens when different counties around San Francisco Bay build or enhance seawalls and levees without coordinating with each other. If communities forge ahead independently with adaptation efforts, SLR impacts get shunted from one area to another (much like floods on the Mississippi get shunted to communities downstream when an upstream community builds up its levees without coordinating with the others downstream). This is an important idea to communicate to decision makers, and it intersects with environmental justice, because this mechanism could lead to communities with fewer resources being confronted with additional impacts diverted from communities with greater resources.

Key Message 9.3. Transformative Adaptation for Coastal Communities. The Committee suggests that the assessment of mitigation and adaptation approaches provide discussion of sensitivity to low-likelihood, high-impact outcomes. The approaches necessarily change under extremes SLR scenarios, and this important consideration is not addressed in the chapter. Within this context, the authors may wish to consider the assessment of flexible adaptation approaches designed to account for the deep uncertainty that characterizes SLR projections, especially those associated with processes of unknown likelihood that correspond to the highest impact outcomes. For example, the authors might discuss Dynamic Adaptive Policy Pathways (see CCB DEEP in IPCC AR6 WG2), and if these ideas are not addressed here, they should be addressed in the adaptation chapter.

Comments on Traceable Accounts

Key Message 9.1. Coastal Hazards Are Increasing Rapidly. The description of confidence and likelihood for Key Message 9.1 does not match statements of confidence and likelihood in the key message itself. For example, the key message states that it is *likely* that “sea level rise along the majority of US coasts is expected to be as much or greater than the observed rise in sea-level over the last 100 years,” but the traceable accounts states that it is *very likely* that “sea levels will rise about 10-12 inches between 2020 and 2050.” These are not analogous statements, and the same can be said for other statements in the key message compared to what is stated in the traceable accounts. The traceable accounts section is meant to directly support the key messages, and that is not done here. Therefore, either the key message or the traceable

accounts should be rewritten such that the content in the traceable accounts directly supports the statements in Key Message 9.1.

Furthermore, there needs to be more detail in the confidence and likelihood section stating which SLR scenarios are used in estimating likelihoods and how these scenarios are used to establish likelihood. One example is lines 1-2 on Page 9-19, which states, “projections show that [SLR] is expected to continue to accelerate in coming decades.” The authors should clarify under which emissions scenarios this is the case and should use the draft NCA5 report confidence/likelihood language instead of the word “expected,” which is not precisely defined by the draft NCA5 report. Another example is where the traceable accounts section states that “It is *very likely* that sea levels will rise about 10-12 inches between 2020 and 2050 based on both trajectories assessed by extrapolating rates and accelerations estimated from historical tide gauge observations and model projections.” This statement is problematic because the phrase *very likely* corresponds to a specific likelihood range of 90-100 percent (Front Matter, Table 2), but the provided range of 10-12 inches is extremely narrow for such a high likelihood. If one downloads the ITF SLR Scenarios for the United States coast,⁴ the 2020-2050 increase for the 50th percentile of each scenario can be calculated to be as follows:

- Low: 7.8 inches
- Intermediate Low: 9.1 inches
- Intermediate: 10.5 inches
- Intermediate High: 13.1 inches
- High: 15.4 inches
- Observation-based extrapolation: 10.7 inches

Assuming the chapter authors seek to base their likelihood assessments on the ITF SLR scenarios, it is unclear how one arrives at a 90-100 percent likelihood range of 10-12 inches from this set of scenarios given that the only model-based scenario that falls within the 10-12 inches range is the Intermediate scenario. Even more problematic is that according to Table 2.4 in the ITF SLR Report, there is only a 10 percent chance that CONUS SLR exceeds the Intermediate scenario for high-emission scenarios resulting in 4°C of global warming by 2100 and only a 23 percent chance for 5°C of warming. Thus, the ITF Intermediate Scenario is not a good central estimate of SLR between 2020 and 2050, and 10-12 inches is not a good estimate of the *very likely* range. The median of the observation-based extrapolation is also within that range, but it has a *likely* (not *very likely*) range of 8.8-12.6 inches, which again suggests 10-12 inches is much too narrow. More work is needed in this chapter to ensure that *all* likelihood statements in Key Message 9.1 (not just the one described above) and its associated traceable accounts are precise and map directly onto NCA5 language regarding likelihood. In cases such as these, it would be preferable to simply use the IPCC SLR projections for which likelihood statements for specific emissions scenarios can readily be made. If the NCA5 authors wish to make likelihood statements based on the ITF scenarios, then more work is needed to develop how to map the discrete ITF SLR scenarios—which are developed based on predetermined amounts of SLR in 2100, not model ensembles—onto NCA5 confidence/likelihood language.

Key Message 9.2. Coastal Impacts on People and Ecosystems Are Increasing. The confidence statements in Key Message 9.2 are reasonable, but the likelihood statements provided

⁴ See <https://sealevel.nasa.gov/task-force-scenario-tool?type=regional&subview=USA>.

in Key Message 9.2 require specific citations in traceable accounts. According to the Front Matter, the “*likelihood* of a finding is based on measures of certainty expressed probabilistically; in other words, based on statistical analysis of observed or projected results or on the authors’ expert judgment based on their assessment across scientific information sources.” Thus, in the absence of quantifiable probabilities (as is the case for statements made in Key Message 9.2), the likelihood should be based on assessment across sources. However, no sources are given in the traceable accounts to support the likelihood statements.

Key Message 9.3. Transformative Adaptation for Coastal Communities. The description of confidence and likelihood restates the statements in Key Message 9.3 and does not provide the *rationale* for the confidence statements as described in the Front Matter (page 0-10, lines 9-12). *High confidence* is attributed to all statements, but it is not stated how the confidence is derived. If the confidence is derived from the literature, sources should be provided.

Comments on Graphics and Boxes

The efficacy of graphics in this chapter is mixed. The graphics target the appropriate audiences in terms of complexity, and the general content of the figures is consistent with the content of the chapter, but the graphics fall short of communicating effectively in multiple cases.

Figure 9.1 shows projections to 2150, but there is only one mention of SLR beyond 2100 in the text, and the statement focuses on the continuation of SLR for millennia (not 2150 as depicted). The Committee suggests that the authors do one of two things. The first (and preferred) option is to add discussion of the 100-year time frame (i.e., 2125) currently depicted in the figure, which can be relevant for infrastructure investment. If this option is chosen, then the deceleration in the higher scenarios beginning at 2100 needs to be explained, as this could be confusing to some. The authors should explain whether these inflections in the rate at 2100 are due to a physical process (in which case the process should be named and described) or whether these inflections are due to the nature of the ensemble used to create the scenarios, which may or may not be homogeneous before and after 2100, as some models do not simulate the post-2100 period. The second option would be to add none of the discussion mentioned above, but in which case the post-2100 period should be excluded from the figure given the lack of discussion and context. Regardless, depicting the post-2100 period without any discussion is not recommended.

Parallel to the issue above, the caption states that “Acceleration of sea level rise in the observed record is expected to continue in all five scenarios (colored lines) through 2150.” This does not appear to be the case based on the depicted curves. The rate decreases around 2050 in the Low scenario. The rate appears approximately constant after 2100 in the Intermediate Low and Intermediate scenarios. The rate decreases around 2100 in the Intermediate High and High scenarios.

As discussed above regarding Key Message 9.1, the Committee strongly suggests that the content of Figure 9.1 be expanded to show the *likely* or *very likely* ranges of the IPCC scenarios in addition to the ITF scenarios. A good example of how to do this is Figure 12.4 in NCA4, where the *very likely* ranges spanned by the various IPCC scenarios in 2100 are provided as bars to the right of the graph. This graphical comparison is needed in NCA5 since the IPCC projection framework is used for every other climate indicator. Thus, the target audiences of NCA5 (i.e., decision makers) should be able to clearly relate the ITF sea-level projections to the SSPs used across the rest of the report. This also provides an opportunity to provide needed context for the higher-end ITF scenarios that represent low-likelihood, high-impact outcomes

associated with low-confidence, physically plausible instabilities in marine ice cliffs. The use-case for these high-end scenarios is the design of expensive and critical infrastructure with long design lifetimes, which can be referenced within the supporting text for Key Message 9.3.

Finally, the authors should be specific about which observations are used for the extrapolations mentioned in the figure caption. There are multiple sources of sea-level data, and general audiences will not know to assume that the CONUS extrapolation is produced via a technique—unspecified in the chapter or traceable accounts—that averages local sea-level observations from an unequally distributed set of tide gauges.

Figure 9.2 mixes “flooding” and “inundation” terminology. These terms have specific meanings that should be defined in the text and should not be used interchangeably unless explicitly stated.

Figure 9.2 also demonstrates a theme of this chapter review, which is that statistics aggregated over the entire United States coastline are not only inadequate indicators of current and future impacts, but they may also be detrimental to the decision-making process by overstating impacts in communities that have not yet experienced frequent flooding events and minimizing impacts in communities currently experiencing frequent events. The observed frequency of minor, moderate, and major flooding varies widely across the United States, and the same goes for projected frequencies in 2050. A key goal of this report is to be relevant for decision makers, and not addressing the regional and local differences in high-tide flooding means that this chapter falls short of that goal. At a minimum, the Committee suggests that an indicator of the range of possible event frequencies across the United States be added to each bar in the figure. Perhaps a thin vertical line could be added to the center of each bar that extends between the minimum and maximum frequency (or some percentile range) across the United States. Further improvement could be made by including three bars (plus vertical lines as described above) for each year and category—one each for east coast, west coast, and islands (Pacific and Caribbean). This would still fall short of being relevant for local decision making, but it would at least give the target audiences some indication of the importance of regional and local variation in the frequency of these events and the need to include such variability in the decision-making process.

The Committee also suggests that the authors provide at least one qualifying sentence noting why coastal communities should be concerned about “minor” flooding. Those not familiar with the terminology may not be aware of the compounding effects over time of many repeated seemingly minor events.

Figures 9.3, 9.4, and 9.5 are potentially useful summaries of concepts in the text, but the lack of effective labeling and captions limits their utility and makes them cumbersome to digest. Readers may not be able to readily connect the limited descriptions in the caption (which in the case of Figure 9.5 does not list the specific adaptation strategies depicted) to the intended components in each graphic. The Committee suggests that these figures be improved by adding relevant labels to the graphics. See Figures 28.1 and 28.6 in Chapter 28 (Southwest) for similar graphics that also include effective labeling.

Comments on Equity and Justice

Chapter 9 (Coastal Effects) provides useful discussion and review of the human dimensions of coastal change, including equity and justice issues regarding disproportionate impacts on under-resourced communities. However, discussion of these issues is weighted

toward economic disparity with less focus on the intersectionality of economics with race and other factors. The chapter could be improved by seeking out and adding references that point out the correlation between race (or other factors) and economics in at-risk coastal communities. Alternatively, the authors could cross-reference other NCA5 chapters if these ideas are discussed elsewhere.

NCA5 will be a widely viewed and referenced document, and it represents an opportunity to inject new—and less controversial or offensive—terminology into climate-related discussions and planning. The Committee suggests the chapter authors refrain from describing communities or groups of people as “marginalized,” because it perpetuates perceptions of inadequacy and lack of autonomy. The Committee suggests using terms that focus on the systemic reasons that a given community may be disproportionately impacted by climate change, such as “overburdened” or “under-resourced.” Similarly, the phrase “managed retreat” may be offensive to the people affected due to the association of the word “retreat” with giving up, while the word “managed” implies that those affected are not in control of the process. A term such as “community-led relocation” may be preferable.⁵

The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Other Recommended Changes

Chapter 9 (Coastal Effects) is not well integrated with the wider draft NCA5 report. There are few links to the physical-science basis chapters (Chapters 2 [Climate Trends] and 3 [Earth System Processes]), which also provide sea-level and coastal information that could be leveraged and discussed here. An overarching theme of this chapter review is the lack of regional and local information, which could be partially remedied by cross-referencing the regional chapters and focusing on providing the needed scientific and adaptation context for the regional chapters. A connection to discussions of economic impacts in the coastal zone elsewhere in the draft NCA5 report would also be welcome.

There are a couple of repeated wording issues that warrant a general statement. First, it is not clear if the terms “flooding” (typically meaning dry becoming temporarily wet) and “inundation” (typically meaning dry becoming permanently wet) are used intentionally or interchangeably. It would be preferable to define these terms to be as clear as possible and then use them consistently. Even if the chapter authors wish to use these terms interchangeably—which is not recommended—this should be explicitly stated because some in the coastal science and adaptation communities do attach specific meaning to these terms. Second, the word “already” is used often, which is (a) an ambiguous term and (b) implies that the described observation or impact is occurring prior to expectations without providing the concomitant expectations. It would be preferable to use words such as “currently” that do not link the observation or impact to unstated expectations.

⁵ See <https://eos.org/opinions/reframing-the-language-of-retreat>.

CHAPTER 10: OCEANS AND MARINE RESOURCES

Summary

This chapter summarizes the ocean changes surrounding the United States and their impacts. In general, the chapter is well written in a consistent, transparent, and credible way and at an appropriate technical level for the intended audiences. It covers a wide range of topics from economic resources to marine ecosystems. However, less discussion is included on the physical and chemical aspects of ocean changes. It may be too late in the process to make a substantial change to the content, and the content is appropriate for this report; thus, the Committee suggests a chapter title change to “Ocean Resources and Ecosystems,” which would more appropriately reflect the content of the chapter. This chapter is not about the ocean system as a whole (i.e., the connected physical, chemical, and biological system) as the title might suggest, but rather impacts on economic resources and marine ecosystems. The key findings presented are well stated and supported by the details provided. The chapter meets the requirements of Section 106 of the GCRA.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction of this chapter is generally well written but reads as an executive summary rather than an introduction. It will be helpful to provide motivation for why readers should care about issues discussed in the chapter—this includes putting the key messages into context, highlighting what is new information since NCA4, and what is not included in the chapter. The definition of ocean economy should be clearly given. For example, does ocean economy include the freshwater component (e.g., the Great Lakes)? It is also not stated what area of the ocean this chapter covers. Is it just the US exclusive economic zone? If so, this should be clarified in the introduction. The introduction should also state that changes across global oceans and their ecosystems affect the United States. References to Chapter 3 (Earth System Processes) and Chapter 17 (Climate Effects on US International Interests) would be useful.

Comments on Key Messages, Supporting Information, and Traceable Accounts

Comments on Key Messages

The key messages are generally well written, consistent, and appropriate. They reflect current understanding about observed and projected impacts to the United States; the challenges, opportunities, and success stories for addressing risk; and identification of emerging issues related to climate change. Key Message 10.1 is an excellent example of a key message that says a lot but uses mostly plain language throughout. However, the first sentence of Key Message 10.1 is confusing because coral reefs also exist in the Arctic; the chapter authors should rephrase this sentence to not compare “warm” areas of the globe (i.e., coral reefs) to “cold” parts of the globe (i.e., Arctic). There are no likelihood statements provided in the key messages. Many of the key message statements seem to be supported by quantitative evidence, and therefore

likelihood statements should also be provided in all three key messages. If there is no quantitative evidence to support the statements, this should be stated in the traceable accounts.

The text supporting the key messages is generally well written and contains sufficient details that provide further evidence. Detailed comments are provided in Appendix A.

Comments on Traceable Accounts

The traceable accounts section is well done and appropriately builds a case describing the authors' process in determining the confidence statements without introducing new concepts or conclusions. The traceable accounts would be more compelling and consistent with the framework for traceable accounts recommended in Chapter 2 of this report if the section on confidence, likelihood, and gaps included more citations.

Comments on Graphics and Boxes

The graphics are well done and are useful summations of the information in the text. They are generally effective, appropriate, and easy to interpret for the intended audiences.

Figures 10.1 and 10.2 are nice figures, but the figure captions should include source(s) and more information about how they were produced. Figure 10.1 should use lines to show that the contiguous United States, Alaska, and Hawai'i and US-Affiliated Pacific Islands are on different maps/scales. Most icons are too small to be very informative in both Figures 10.1 and 10.2.

Figure 10.5 is from the Center for American Progress. Chapter authors may consider choosing a different figure that is not from a left-leaning advocacy organization. Also, schematic figures like Figure 10.5 should have captions with some explanation of how and from where the findings in the figure were generated.

Comments on Equity and Justice

The committee suggests stronger framing of equity and justice-related issues in the introduction, as well as related dimensions of equity as relevant to oceans and marine resources. Context on historical and systemic drivers of vulnerability or disparity should be offered where appropriate.

The importance of access to knowledge and information is well addressed, as is the discussion of governance. There is mention of equity in the introduction and in the "Adaptation and Mitigation" section, but the connections in subsequent sections are not sufficiently explained. In general, issues of equity and justice are not well-developed outside of the somewhat narrow focus on disproportionate impacts to coastal Indigenous communities. It is not clear whether this is due to a lack of literature on disparate impacts of ocean change across racial and/or socioeconomic boundaries. If that is the case, it could be added as an area of uncertainty and research gap in the traceable accounts.

In Key Message 10.1, "human well-being" should be defined. In Key Message 10.2, equity and justice framing could be incorporated into benefits and burdens of impacts and adaptation measures described—who is likely to benefit and who will be left out unless intentional measures are taken?

There are opportunities to discuss where conservation efforts are most concentrated and who is benefiting the most (e.g., SLR protection measures). The text (i.e., page 10-12, lines 21-

23) should explain which communities are being more harmed by flooding and pollution. For example, more context should be given on the impact of black carbon on communities, which communities are most affected, and the structures of decision making that enable and perpetuate such harms. There are also opportunities to discuss issues related to the “not in my back yard” sentiment often associated with renewable offshore energy.

The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible. Finally, specific gaps in equity- and justice-related literature with respect to the chapter focus should be noted in the text or traceable accounts.

Comments on Data and Analyses

All the results adopted from other sources and presented in this chapter seem appropriate. There is a section discussing the needs of data and the importance of data accessibility, which is helpful.

Comments on Literature Cited

Overall, appropriate literature is cited, though the use of a broader knowledge base should be explored. The literature review appears robust and mostly focused on publications since NCA4.

Other Recommended Changes

In the section on commercial fisheries (page 10-10, lines 1-24), the text implicitly blames all changes in fishery productivity on climate change, when other issues (e.g., overfishing) could also be responsible or at least have compounding effects. The text should more clearly separate these issues. Not until the third paragraph of the section is it hinted at that many of the fisheries could be overfished currently. There are already many stressors on fishery productivity (especially overfishing), which are then exacerbated by climate change.

The discussion on the importance of the ocean observing system (“Data and Research” on page 10-16) is helpful. However, the authors could expand from the narrow biological focus and highlight that observing the entire ocean system (physical, chemical, and biological aspects) using both in situ and remote sensing techniques is critical. Research cruises to assess fish stocks, and satellite missions to detect marine heat waves or phytoplankton distributions, for example, are significant and critical national investments in our collective ability to quantify and predict the impacts of climate change, which in turn determines the evolving human and policy response. NCA5 should emphasize that the nationwide environmental observing system requires continued investment. It is an essential component of the ongoing ability of the United States to track and respond to climate change.

Lastly, the text should also specify which scenarios are being referenced if they are different from the scenarios introduced in the Front Matter. Appendix A includes detailed comments on this point.

CHAPTER 11: AGRICULTURE, FOOD SYSTEMS, AND RURAL COMMUNITIES

Summary

Agriculture is a crucial component of the US economy. Agriculture is unique in that it is both a source and a sink for GHGs. At the same time, agriculture provides nutrition for a diverse population. This chapter meets the requirements of Section 106 of the GCRA, with the exception of adequate projections 25 to 100 years into the future and is written at the appropriate technical level. Given the importance of agriculture, this chapter needs to better explain the positive and negative impacts of climate change on production as it cascades up through the supply chain. The chapter focuses on growing season length, but this is not a critical challenge for agriculture. The key aspect of climate change for agriculture production is extreme events and uncertainties that impact production. The other key aspects are mitigation and adaptation strategies for both crops and livestock. The US government and the private sector are making significant investments in climate-smart practices, but the chapter does not acknowledge these investments. The chapter also discusses climate change impacts beyond the farm gate. This is important and could benefit from further discussion on impacts, mitigation, and adaptation measures. The chapter recognizes the impact of climate change on rural communities and Indigenous populations, but some additional discussion could be added.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

Overall, the introduction could provide a better road map for the rest of the chapter. The introduction cites unpredictable weather as one challenge but refers to the regional chapters as examples. Unpredictable weather is probably the most severe challenge facing agriculture production. This chapter should provide an overview of the issues, and more specific examples can be provided in the regional chapters. Shifting plant hardiness zones and growing season lengths are not the only challenges. Changes in plant hardiness zones could be seen as positives or negatives. The change in the intensity and seasonality of precipitation and temperature are a cause for concern, which should be explained. The temperature effects on plant growth stages are more severe than the annual changes in temperature. For example, early bud break on fruit trees followed by a cold snap is more damaging than longer growing seasons. The chapter rightly highlights the effect of extreme events as becoming more intense and frequent, but this is not well documented. The introduction should also state the potential synergies between mitigation and adaptation to climate change. The chapter could be more explicit about mitigation and adaptation options. Agriculture is a complex system and meets societal needs for food, fuel, and fiber. It is also a source and a sink for GHG emissions. A systems approach is needed that includes best practices and technology (e.g., breeding, precision agriculture, precision conservation, new crops). In some cases, mitigation options improve productivity and resilience.

Comments on Key Messages, Supporting Information, and Traceable Accounts

Overall, the key messages in this chapter are done well, and the key message titles that communicate a message can be used as examples in other chapters. However, there are a number of key issues that do not receive sufficient attention, and suggestions are made below of areas to emphasize. Key Message 11.1 seems like two distinct key messages and should be considered in light of feedback below.

Comments on Key Message Language and Supporting Text**Key Message 11.1. Agricultural Adaptation in an Evolving Landscape**

Climate change has increased agricultural production risks by disrupting growing zones and growing days, which are dependent on precipitation, air temperature, and soil moisture (*very likely, very high confidence*). Growing evidence for positive environmental and economic outcomes of conservation management has led to greater farmer and rancher adoption of agroecological practices (*very high confidence*) which increases the potential for agricultural producers to limit greenhouse gas emissions (*likely, medium confidence*) and improve agricultural resilience to climate change (*high confidence*).

Suggested title: “Agricultural Adaptation and Mitigation in an Evolving Landscape.”

The first part of Key Message 11.1 does not agree with the literature. Growing zones and growing degree days can be seen as positive, except crops might require additional inputs (i.e., herbicides, pesticides, and nutrients) to accommodate the additional growing period. One problem is the increased weather variability and extremes in temperature and precipitation. For example, early heat stress in April can devastate wheat crops. The Committee suggests removing Figure 11.4 on plant hardiness zones. Migration of plant hardiness zones could be a benefit, especially in the higher latitudes.

The Committee is surprised that the chapter authors chose agroecology principles to provide resilience to climate change. Some define agroecology as not utilizing technology or any synthetic inputs. The chapter needs to clearly define terms and intent. The USDA has been using the terms “climate-smart practices” or “conservation practices.” These terms are more commonly accepted within the agricultural community. US agriculture has promoted no-tillage agriculture with cover crops and crop diversity (rotations). Agroecology sometimes promotes polyculture and no chemicals. Agroecology is not the prevailing terminology in US agriculture.

This key message does not mention technologies to improve resilience and reduce inputs. Precision conservation should be discussed. For example, sensors could reduce inputs, especially nitrogen and water. Biotechnology options included deep rooted crops and changes in root architecture. The National Academies have reported on soil carbon sequestration technologies and ways to reduce emissions in agriculture (e.g., NASEM, 2019). Robotics and drones could reduce nutrients, water, pesticides, and energy inputs. The chapter would benefit from a table on technologies to reduce greenhouse emissions (i.e., N₂O and methane) and enhance soil carbon. The chapter could also relatively rank the scale of mitigation impacts. Reducing food waste and consumption also are mitigation options. The role of biofuels is not discussed especially since this is a major US policy. The evidence basis for the magnitude of mitigation provided by biofuels may be inconclusive. This could be briefly explored in this chapter, in the general text or in traceable accounts discussion.

Water use in agriculture is an evolving issue and is complicated by climate change. For example, precipitation in the Ogallala aquifer region is expected to decrease and evapotranspiration increase. This scenario exacerbates the declining water availability in the Ogallala aquifer. Energy reduction could be realized with irrigation technologies. This issue is not confined to the Ogallala region but is also relevant to California, Florida, and other areas of US agriculture and should be mentioned.

The discussion of mitigation options for methane production in US agriculture could be expanded. The text does not give the reader a sense of the mitigation options. The text says there is much variability in production systems, but the reader is not provided with any solutions. The text should provide some citations for cell-cultured meat instead of just mentioning it. The data source presented in Figure 11.10 is for global production, not US production, which should be lower.

It is surprising that the chapter does not mention any USDA programs except for the Conservation Reserve Program and Environmental Quality Incentives Program. The current administration has spent more than \$2 billion on climate-smart commodities, released last April 2021. The chapter should mention this investment in potential climate reductions for US agriculture. Both government programs and private sector investments are being made in US agriculture for climate-smart practices and ecosystem services, including carbon sequestration, which should be mentioned.

There has been an increase in wildfires in the Great Plains, which is mentioned in several regional chapters. There is no mention of wildfires and their effect on grazing land systems. As an example, a wildfire outbreak in Kansas in December 2021 burned more than 163,000 acres (66,000 ha) in portions of western and central Kansas, resulting in two deaths and more than 42 structures destroyed. The windstorm and wildfires caused more than \$2.3 million in damages, and many cattle were lost from the fires.

Drought and heat also affect livestock. The chapter could mention the effect of extended drought and its impact on animal agriculture. In the past decade, several droughts have occurred, and cattle had to be moved from the Southern Great Plains to the Northern Great Plains. This affected production and transportation costs. There was a connection to the reduction in the cattle herd, and meat prices could be used as a case study or an example. This is an example where one part of the United States impacted by climate change affects the production of the entire United States. There was an instance in the spring of 2022 where several thousand head of cattle died because of an early heat wave.

Lastly, there are cases where climate change is positive. In the Northern Great Plains, warmer temperatures have allowed for planting higher-value grain crops such as corn.

Key Message 11.2. Climate Change Disrupts Our Food Systems in Uneven Ways

Climate change is projected to reduce the availability and affordability of nutritious food (*likely, medium confidence*). These risks to food security create social and economic challenges, some of which are distributed unevenly, including worsening heat stress among farmworkers (*high confidence*) and increasing food prices (*medium confidence*). Climate change has disrupted the ability of subsistence-based people to obtain food through hunting, fishing, and foraging (*high confidence*).

This key message is reasonable. However, with current technology and agricultural adaptation, the United States has not seen a change in availability and affordability of food. This is also mentioned in the traceable accounts. The question is how adaptable US agriculture is across the different states.

Key Message 11.3. Rural Communities Face Challenges and Opportunities

Rural communities steward much of the Nation's land and natural resources, which provide food, bioproducts, and ecosystem services (*high confidence*). These crucial roles are at risk as climate change compounds existing stressors such as poverty, unemployment, and depopulation (*medium confidence*). Opportunities exist for rural communities to increase their resilience to climate change and protect rural livelihoods (*high confidence*).

The discussion on rural community resilience is useful for this chapter. However, the space devoted to explaining the Baseline Resilience Indicators for Communities (BRIC) Index is not helpful and could be included in Chapter 20 (Social Systems and Justice) because many of the BRIC principles do not apply to this particular chapter. The Committee suggests reducing the explanation of BRIC, which would allow more space to be devoted to climate variability and the impact on agricultural production and food systems.

Comments on Traceable Accounts

In general, the traceable accounts for Key Messages 11.2 and 11.3 are well supported and described.

Production constraints induced by climate affect distribution across the United States. In the traceable accounts section, the authors describe the process by which they decided to minimize the discussion on production and focus on food systems. The authors could provide examples where climate disasters have shifted production from one area of the country to another if they want to discuss the supply chain.

In the traceable account for Key Message 11.1, the authors cite literature that supports the evidence for increased variability and vulnerability. They also provide citations for technological solutions. However, in the main text, technology such as digital agriculture, information technology, and other options is not discussed as an adaptation or a mitigation tool. New citations should not be introduced in the traceable account; instead, the literature in the main body should be used as supporting evidence. The citations provided for adopting practices are focused on conservation, not agroecological practices discussed in the text. There is a disconnect between the terminology that uses agroecology and the more commonly used language within conservation agriculture, climate-smart agriculture, or other terms in current US agriculture. The Committee does not believe the authors use agroecology incorrectly but suggests that the authors improve and focus its discussion by using the terminology and conceptual framework of climate smart agriculture. This terminology is more current and specifically focused on climate mitigation and adaptation, while agroecology is a general technical framework concerning broad environmental management of agricultural production systems incorporating ecological concepts.

Comments on Graphics and Boxes

Figure 11.3 is not the first figure of ecosystem services in the draft NCA5 report. Consider cross referencing with other chapters to use one model consistently throughout NCA5 or present the concept of ecosystem services in Chapter 1 (Overview) and reference back to it.

In Figure 11.4, the plant hardiness zone does not represent the impact of climate change. Graphs illustrating weather extremes would be more appropriate, such as a change in precipitation intensity and increased rangeland wildfires (e.g., figures from the National Oceanic and Atmospheric Administration [NOAA] showing the change in the intensity and aerial extent of droughts). This figure should either include Alaska, Hawai‘i, and the US Caribbean or explain why they are missing in the caption. In addition, please include in the caption which scenario is being used for this projection.

In general, the figure captions should be longer throughout this chapter to ensure that figures are self-contained. Also, schematic figures like Figure 11.5 should have captions with some indication of how/where the findings in the figure were generated.

Regarding Figure 11.6, agroecology is not the most commonly used terminology, as described above. Agroecology principles are more associated with small-holding farming and eliminating technological inputs. A similar illustration could be used for climate-smart agriculture or regenerative agriculture. In the current figure, the text on top of the photo is difficult to reach; consider adding shading behind the text so it stands out more.

Figure 11.7 is not available for the Committee to comment on, although it might be better to use a figure from a scientific publication rather than from the American Farm Bureau.

The caption of Figure 11.8 does not incorporate all the elements in the figure. Rather than only showing incorporating perennial production into the landscape, a full menu of climate-smart practices or regenerative agriculture would make a better illustration.

Figure 11.9 is relatively basic and does not capture the variety of livestock production. There should be a separation between types of livestock. For example, beef and dairy produce more methane than hogs or chickens. This figure lumps livestock as one single unit. This figure also does not illustrate the avenues for adaptation or mitigation.

The source for Figure 11.10 is global agriculture and not the United States. The US livestock emissions should be much lower than the global emissions. This graph could be very useful if it were put in the US context.

Figure 11.14 is important because it shows the GHG emissions along the food supply chain. This figure could be used to discuss mitigation options through the food supply chain in the text.

The discussion of considerable spatial variability in resilience to natural hazards in Figures 11.15 and 11.16 is essential to policy and planning decisions. However, it may be worth discussing the placement of these figures with the authors of Chapter 20 (Social Systems and Justice).

Comments on Equity and Justice

The committee suggests stronger framing of equity- and justice-related issues in the introduction, as well as related dimensions of equity (distribution of benefits and burdens, procedural, recognition, intergenerational equity) as relevant to agriculture, food systems, and

rural communities throughout the chapter. Context on historical and systemic drivers of vulnerability or disparity should be offered where appropriate.

Specifically, this chapter should note connections to structural factors that drive inequitable nutritional outcomes. For instance, food deserts occur in both urban and rural areas causing the lack of availability of nutritious food. In addition, historical connections to current structures maintain inequitable agricultural support that determines who benefits and who bears the burdens, who participates, and recognizes sources of knowledge, and this should be acknowledged. The current administration has tried to compensate Black farmers with additional funding support, and this initiative should be mentioned. Climate smart agriculture could also be discussed in the context of equity, identifying benefits and burdens and their distribution, and power structures that may perpetuate inequities.

Specifically, page 11-12, line 17, should comment on the issues of data accessibility. Page 11-13, lines 26-28, should expand on concerns raised by Indigenous communities. Page 11-18, lines 6-20, should discuss children experiencing food insecurity and intergenerational impacts.

The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible. Finally, specific gaps in equity- and justice-related literature with respect to the chapter focus should be noted.

Comments on Literature Cited

The chapter does not include some technological tools for climate adaptation and mitigation. Additional references would add to the discussion in this chapter (Basso, 2021; Cheng et al., 2022; Field et al., 2020; Gaffney et al., 2019; Hatfield et al., 2018; Khanna et al., 2021; Lark et al., 2022; Liu and Basso, 2020; Martinez-Feria and Basso, 2020; Martinez-Feria et al., 2022; Northrup et al., 2021; Ortiz-Bobea et al., 2019; Schulte et al., 2022; Yang et al., 2022).

Other Recommended Changes

There is no discussion of biofuels in this chapter. Many states and federal programs support biofuels, including biodiesel and ethanol production. Furthermore, the evidence basis for the magnitude of mitigation provided by biofuels may be inconclusive, and this could be briefly explored in this chapter, in the general text or in traceable accounts discussion. In addition to ethanol production from corn, the byproduct is distillers' grain, which can then be used for livestock feed. This is a major contribution of agriculture to substituting fossil fuels for renewable energy and should be mentioned.

Another consideration is the dual purpose of agriculture production with wind or solar production. Much of the central United States has wind production on agricultural landscapes. There was one statement on agrivoltaics, but no citations were provided.

Finally, there is no discussion on reducing food waste and loss. If the chapter will focus on the food system as noted in the traceable accounts, then reducing food waste should be discussed because it would reduce GHG emissions and production inputs.

CHAPTER 12: BUILT ENVIRONMENT, URBAN SYSTEMS, AND CITIES

Summary

Chapter 12 (Built Environment, Urban Systems, and Cities) adequately addresses the requirements of Section 106 of the GCRA, with the exception of providing projections 100 years into the future. The introduction is clear and compelling, but overall, the chapter is very technical, and, in many instances, specific themes should be rephrased for accessibility so that all sections are digestible and of interest to the broadest possible audiences.

The key messages and supporting text are well written, and sufficiently supported by the subsequent text, but the Committee suggests that text of the key messages be reordered and, in some instances, rephrased in a succinct way for readability. It is likely that language lacking in other chapters is consistently used in this chapter. The findings in this chapter are mostly clear, concise, consistent, and supported by credible, timely research. A broad number of resources are used and referenced, with some exceptions, including Table 12.1 where the Committee encourages additional citations be included.

Overall, this chapter is balanced, informative, and well referenced. However, and most critically, there should be a clearer definition of the built environment explicitly stated in the introduction that aligns with the focus of the chapter. As written, this chapter focuses on urban areas and cities, and cities and built environment are used interchangeably throughout this chapter. The chapter authors should consider either focusing on urban/cities more explicitly or having a more balanced approach to describing built environments that are not urban/cities. There is also an opportunity in this chapter to highlight built environments like the wildland-urban interface, which could reference Chapter 7 (Forests), or emphasize additional built environment systems like, stormwater. These additions may help frame topics that are or are not being covered within the chapter. Either way, the Committee suggests expanding the discussion on non-urban areas as well as referencing the intersectionality between rural and urban areas. The Committee also suggests, where appropriate, cross-referencing other chapters to both highlight the interconnected nature of topics across the report, as well as to help the chapter expand on themes without increasing the word count significantly.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction is an opportunity to focus on readability for broad audiences. As currently written, the introduction is not as compelling as it could be, nor does it provide the relevant context or background to support the key messages. Using language like “recent science highlights” is passive and lacks urgency. The chapter authors should consider revising the introduction to clearly define the built environment so that it aligns with the focus of the chapter and introduce the key messages that are the focus of subsequent sections. Specifically, Key Message 12.2 says, “Climate impacts create negative and cascading effects on the built environment, with many systems either projected or observed to be at risk of failing.” The Committee suggests using this key message as an example for clear and accessible language that should be used throughout the chapter. Additionally, the second paragraph of the introduction

presents one of many opportunities to link to other chapters including Chapters 5 (Energy Supply, Delivery, and Demand), 6 (Land Cover and Land-Use Change), 7 (Forests) 18 (Sector Interactions, Multiple Stressors, and Complex Systems), 31 (Adaptation), and 32 (Mitigation). Furthermore, the wildland-urban interface is an important facet of urban changes with climate related aspects such as increase wildfire, so the Committee suggests better integration with Chapters 7 (Forests) and 8 (Ecosystems, Ecosystem Services, and Biodiversity).

Comments on Key Messages, Supporting Information, and Traceable Accounts

Overall, key message titles are written as general labels. Aligned with the recommendation in Chapter 2 in this report, the Committee suggests chapter authors consider providing titles that are more declarative, written as short, informative statements. Rewriting titles as such will make the key messages more effective and impactful. Some of the key messages could also use additional clarification as to their relationship to the definition of built environment, urban systems, and cities, as these topics are not as interchangeable as this chapter suggests. The assessments of confidence and likelihood are communicated effectively and correspond with a strong traceable accounts section. The text supporting the key messages is communicated effectively, except for some line edit suggestions in Appendix A.

Comments on Specific Key Message Language

Key Message 12.1. Urban Areas as Drivers and Centers of Climate Change

Consumption of food, energy, and materials in urban areas is a driver of global climate change (*likely, high confidence*). Changes in land use, development, and human settlement patterns have driven and will continue to drive local and regional climate change in and near urban areas (*virtually certain, high confidence*).

Suggested title: “Urban Areas Are Drivers of and Centers for Climate Change Impacts.”

Key Message 12.2. Key Climate Impacts, Risks, and Vulnerabilities in the Built Environment

Climate change is already amplifying existing loads on the built environment and is burdening urban communities, and these impacts will intensify over the next decades (*virtually certain, high confidence*). Cities concentrate risks given current levels of infrastructure deficits, unequal exposure of people and assets, and high levels of socioeconomic inequalities (*virtually certain, high confidence*).

Suggested title: “Attributes of the Built Environment Create Climate Impacts, Risks, and Vulnerabilities.”

Key Message 12.3. Urban Climate Mitigation and Adaptation Opportunities

Cities across the United States are mitigating greenhouse gas emissions and adapting to adverse climate impacts (*likely, high confidence*). Although some states and cities are integrating climate considerations into relevant codes, standards, and policies, the pace, scale, and scope of action are not yet sufficient given the magnitude of observed and projected climate changes (*virtually certain, high confidence*).

Suggested title: “Urban Environments Create Opportunities for Climate Mitigation and Adaptation Measures.”

Key Message 12.4. Fairness in Urban Climate Governance

Urban plans show varying progress in considering who benefits or bears the burden of climate investment and efforts (*very likely, high confidence*). The emergence of local and community-led approaches—coupled with increasing collaboration among city, tribal, state, and federal governments—delineates a shift toward inclusive planning and implementation (*likely, high confidence*).

Suggested title: “Equitable Climate Investments and Planning by Communities Are Important.”

Comments on Text Supporting the Key Messages

Key Message 12.1. Urban Areas as Drivers and Centers of Climate Change. This section appropriately identifies the challenges, opportunities, and success stories with a range of broad examples, though the Committee suggests also including more specific examples that would be more compelling. Specifically, resource consumption and land use impacts will drive local and regional climate change. The Committee suggests including specific information on the impacts of pavements or traditional roofs versus interventions like cool streets, cool roofs, or green stormwater infrastructure, or including urban areas examples. This key message is very important, and the lack of examples is a missed opportunity.

Key Message 12.2. Key Climate Impacts, Risks, and Vulnerabilities in the Built Environment. This section appropriately identifies the challenges, opportunities, and success stories with a range of broad examples, though the Committee suggests also including more specific examples as they would be more compelling. Cities concentrate risks that are amplified by infrastructure deficits, unequal exposure, and inequality. The Committee appreciates the discussion of the perilous state of US infrastructure, which will require unprecedented investment. The Committee suggests elaborating on the opportunity for infrastructure investment and climate change response as mitigation and adaptation responses.

Key Message 12.3. Urban Climate Mitigation and Adaptation Opportunities. This section appropriately identifies the challenges, opportunities, and success stories with a range of broad examples, though the Committee suggests also including more specific examples as they would be more compelling.

Key Message 12.4. Fairness in Urban Climate Governance. This section appropriately identifies the challenges, opportunities, and success stories with a range of broad examples, though the Committee suggests also including more specific examples as they would be more compelling. However, the Committee suggests revising the first full paragraph on page 12-19, lines 3-12. While overall this section is well done, there are some outstanding questions that are not addressed in relation to “Fairness in Urban Climate Governance.” For example, who pays and who benefits? Additionally, this section could use graphics and perhaps a memorable concrete example.

Comments on Traceable Accounts

The traceable accounts are clear and provide sufficient context for the embedded text that reflects the current understanding of the state of the science. Specifically, the traceable accounts adequately explain the basis for confidence/likelihood assignments. However, at the beginning of the traceable accounts, the authors identify eight topical areas for the literature search. These areas may have been prescribed, but if they were not, the Committee suggests not listing urban social equity and justice as last, so as not to have it appear as an afterthought.

Comments on Graphics and Boxes

Some of the images and graphics for this section were not available to the Committee to review. Many of the maps and graphics provided are sufficient, and the Committee commends the authors for these self-contained figures that have good captions that describe both the data sources used as well as what is missing. However, many of the graphics chosen for this chapter do not add to the narrative. The Committee suggests focusing on updating Table 12.1 as detailed below and to consider removing or replacing Figures 12.6 and 12.7.

Figure 12.1 documents emissions across the United States and how this largely reflects patterns of human habitation, but the data included are from 2015. If available, the Committee suggests using updated data to create this figure. Additionally, authors should consider adding boxes around the parts of the map that show that it is at different scales/locations, and boxes that “zoom in” on a particular region(s) of interest. Also, the caption should cite more precisely the data sources, and clear labels would also be helpful.

Figure 12.2 is a useful idea, but at a nationwide scale, lacks the details to be useful. The Committee suggests focusing on an area that is predicted to have rapid change.

Figure 12.3 categorizes many land-uses into five typologies. However, the graphics could be improved, and it may be helpful to reevaluate which cities are highlighted in the heavy industry section. Additionally, the Committee suggests explaining what different impacts these building types might have on urban climate and temperatures in the caption.

Figure 12.5 has not yet cleared copyright, but it should reflect the day and night heat differences and why these are important. Additionally, the figure caption should clarify the links between the urban heat island effect (which itself is not directly caused by climate change per se) and climate change.

Figure 12.6 highlights the important correlation between local heat increases and median household income declines. However, the complexity of the graphic might be lost on broad audiences. The Committee suggests simplifying the caption to make the figure more accessible. Also, if there is no particular order for the maps, the Committee suggests alphabetical order.

Figure 12.7 is ineffective and is unlikely to inform the public or policy makers. The Committee suggests removing this figure or replacing it with a specific example. If kept, the figure should include additional examples to make it more relevant.

Figure 12.8 captures Table 12.2 well; however, it is difficult to read. The Committee suggests enlarging the graphic and moving the legend on the bottom of the figure so that the icons can also be enlarged.

Table 12.1 provides examples of climate risks to the built environment and projected losses to 2090. This is very ambitious in scope for economic losses in 2090. The Committee is unsure whether the precise numbers for 68 years from now are useful or realistic because dollar

value numbers associated with such projections are hard to interpret without a measure of the assumed size of the economy in 68 years. Also, the table would be enhanced by citing multiple sources for the data included or providing an explanation for the heavy reliance on one source. It is also unclear if staggering estimated cost of more than \$150 trillion from one year of SRL is a US cost or a global one and should be clarified. As these findings are so alarming, they should be referenced more effectively and consistently with multiple sources. In addition to the RCP names, chapter authors should consider using the scenario labels as described in the Front Matter to make the table more accessible. Finally, the Committee suggests either focusing on this table and ensuring that the information is complete and more robust by including additional sectors (e.g., sewers, schools, medical facilities, telecommunications) with additional information and sources, or re-envisioning the table in another way.

Table 12.2 highlights perhaps the most important information in the chapter and should be carefully crafted to be a self-contained and accessible table to broad audiences, and chapter authors should consider moving it to the introduction. Additionally, NCA5 authors may consider expanding each category to include more detail. For example, disaster and management should require changes in building permits, construction, flood insurance; the authors should ensure that both public and private insurance for flood or for violent weather have costs and premiums that reflect reasonably anticipated damage. One significant omission from this table is walking, yet it is the primary exercise of Americans, more than biking and running. NCA5 authors should also consider adding ferries/boats (including electric) in urban transport. Additionally, terminology should be used more carefully. Managed retreat language should be rephrased to be inclusive and consistent with other chapters, and the phrase “tree canopy” should replace “street trees.” Finally, the Committee suggests referencing minimizing parking under building options.

Table 12.3 has good examples but is too general. The Committee suggests using specifics which could potentially be done by linking to appropriate examples already in the regional chapters.

Box 12.1 does not have a clear focus and therefore as written is not effective. The Committee suggests clarifying if this box is focused on cities/urban environments or any local government, suburban, or rural areas. Additionally, the title should be updated to reflect the intent. Often boxes are best for examples and are more impactful that way. However, there is no discussion about public-private partnerships as an investment strategy.

Comments on Equity and Justice

Equity and justice principles are adequately incorporated throughout the chapter, though more specific examples could be used to better illustrate the disproportionate impacts of climate change on historically overburdened populations. For example, the chapter could reference that Houston’s urban heat island mapping showed a 17-degree difference between two neighborhoods at the same time and on the same day. Historically disadvantaged communities language may be updated to be consistent with the recommended equity and justice glossary and/or other chapters for greater consistency. Additionally, a missing area that ties together climate change, extreme precipitation, storm water, urban areas, and equity and justice principles, is the increasing inability of urban areas, particularly in communities least able to respond, to adequately manage storm water from intense storms. This could and should be a strong integrating theme of this chapter, but it is understated. This is critical due to recent trends which are likely to be sustained.

Additionally, the Committee suggests using “resident” rather than “citizen” when describing community members, for greater inclusivity. Managed retreat language should also be sensitive to communities being displaced. There is an opportunity to broaden this language, consistent with other chapters. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Data and Analyses

As detailed above, there is an opportunity to use more recent data, ideally available since NCA4, to ensure the most current information is being presented. If recent data are not available, this should be noted as a research gap. Additionally, data analysis is not always presented clearly with sufficient supporting information, which makes it challenging to confirm its credibility and if it is applied appropriately.

Comments on Literature Cited

This chapter accurately reflects the knowledge base and incorporates ample recent literature appropriate for NCA5. However, authors should include citation when discussing uncertainties in the traceable accounts.

CHAPTER 13: TRANSPORTATION

Summary

The chapter provides a thorough discussion of the US transportation network; however, it does not yet meet the requirements of Section 106 of the GCRA due to its lack of documentation for the findings in a consistent, transparent, and credible way in the traceable accounts section. Overall, the chapter is written at an appropriate technical level for the intended audiences, and the key messages are well stated and supported by details in the chapter. The traceable accounts could be improved to better support the key messages by providing likelihood statements, where appropriate; including citations; and including major knowledge gaps. The chapter should also add cross-references to other relevant chapters (e.g., Chapters 6 [Land Cover and Land-Use Change], 12 [Build Environment, Urban Systems, and Cities], 14 [Air Quality]).

Additionally, the chapter does not address mobility, so there is an imbalance in which types of transport modes are covered. Since this chapter is short overall, there is an opportunity to add more text. The chapter introduction could be expanded to include a discussion on mobility, movement of people, and transport futures for people. The chapter should also add text in Key Message 13.2 on alternative transport modes, particularly public transportation, shared mobility, and micromobility. Additionally, a central challenge for transportation and climate change is the automobile-dominated transport system. This chapter should address how the United States is transitioning from an auto-dependent system to alternative, low-carbon transport modes.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

This is a very well written introduction with a good use of plain language. The inclusion of what previous assessments discussed is a strength. However, the introduction should explicitly discuss mobility, how people move, and who is impacted by transportation vulnerabilities. The introduction is also a chance to make more connections to urban and rural transportation. The introduction notes that previous assessments highlighted risks arising from not considering climate change when investing in transportation but could more clearly discuss how the state of knowledge has advanced since NCA4.

Comments on Key Messages, Supporting Information, and Traceable Accounts

Comments on Specific Key Message Language

The key message titles should be short, informative statements rather than descriptions. For example, Key Message 13.2 could be titled “Climate Change Is Requiring the Transportation Sector to Change” instead of “A Changing Transportation Sector.” Additionally, the key messages are all missing likelihood statements; these should be added if there is quantitative evidence to support these messages.

Key Message 13.1. Limiting Emissions and Managing Risk

The transportation sector remains the largest source of greenhouse gas emissions, although transportation emissions sources are changing (*very high confidence*). The industry also faces increasing risk from climate-related extreme weather (*very high confidence*). Strategies incorporating climate data into transportation planning, design, operations, and maintenance can reduce such risks to the sector (*very high confidence*).

The last sentence of Key Message 13.1 is confusing wording. The Committee suggests removing the word “strategies” for clarity.

Comments on Text Supporting the Key Messages

Key Message 13.1. Limiting Emissions and Managing Risk. This section discusses transportation as the largest source of greenhouse gas emissions and notes that climate change poses a significant risk to transportation infrastructure. While the section mentions the marine sector, chapter authors should include interstate water systems, particularly the Mississippi system. These systems have a different set of issues and particular sensitivities. In Table 13.1, the inclusion of pipelines as a transport mode is a great addition.

Key Message 13.2. A Changing Transportation Sector. This section explores changes in terms of technology in transportation and workforce development needs, with a particular focus on an aging workforce. The Committee appreciates the discussion of workforce development. However, on page 13-12, there should also be a discussion of the supply chain constraints in auto manufacturing as well as inflation, and the resulting impact on prices for consumers. Additionally, while the section identifies persistent underrepresentation of women

and people of color as a workforce challenge, it is important to add a citation as well as statistics to support these statements.

Key Message 13.3. Co-benefits of Mitigation and Adaptation. The section discusses reductions in air pollution and health benefits, while touching upon exposure disparities. However, this section omits an important discussion on tire and road wear as well as the impact on the electric grid from electrification. Furthermore, similar Chapter 12 (Built Environment, Urban Systems, and Cities), there is an urban focus that lacks rural analysis, such as challenges with expanding the grid to electrify rural areas. One suggestion is to differentiate the co-benefits of fuel switching from coal to natural gas to those involved in a switch to renewable energy and other non-emitting sources.

Key Message 13.4. Transportation Trade-Offs. The section discusses the potential for solutions to differentially impact different groups. One important trade-off to also discuss is the decreased need for maintenance of electric vehicles, including the need for reeducating the workforce and the potential for displacement of workers who tend to have lower socioeconomic status.

Comments on Traceable Accounts

The traceable accounts do not support key messages or supporting text in this chapter as there are currently no citations. The section is missing a discussion of what literature was used to draw conclusions in the key messages and does not identify gaps in the literature. Revisions are needed in order to support the credibility of the key messages. Authors should refer to the recommended framework on traceable accounts in Chapter 2 of this report to ensure consistency and credibility across NCA5.

The traceable account for Key Message 13.1 mentions precipitation guidelines for hydraulic design. However, that topic is not well represented in this chapter, including examples of loss and damage as well as instances of new design practices and results. The traceable account should not introduce new literature that is not already in the chapter; instead, it should explain support for the key messages. The effects of CO₂ on cognition is a major research gap that should be mentioned. For the traceable account for Key Message 13.2, CO₂ emission implications of design and construction choices, sourcing of low-emission materials, and verification of their emission profiles and attendant costs should also be added as major gaps in knowledge. The traceable account for Key Message 13.4 should mention the implications of different battery chemistries, such as iron versus lithium, in the gaps section.

Comments on Graphics and Boxes

Overall, the figures are well done, and some minor changes would make them even more effective.

For Figure 13.1, black text for the figure labels would make it easier to read.

In general, icons and graphics should only be used when they help communicate the ideas. In Figure 13.4, the trucks and planes make the overall figure more complicated where a simple bar chart might be better. Instead, icons next to words/bars could be added to enhance understanding by reinforcing the words with a visual.

Figure 13.5 is not effective and could be deleted if more room were needed.

References are needed in the caption of Figure 13.6. Schematic figures like Figure 13.6 should have captions with some indication of how/where the findings in the figure were generated. “George Washington University and Jacobs” tells the reader very little about where the data in this figure came from.

Comments on Equity and Justice

Equity and justice issues are well integrated in the introduction and throughout chapter. The Committee appreciates that there is some discussion of self-determination. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters where possible.

Comments on Data and Analyses

The caption for Table 13.1 indicates that some areas have a scarcity of research. However, the current literature and traceable accounts suggest that the literature review was not comprehensive enough to conclude that there is a scarcity. There has been extensive research since NCA4. There are so many potential citations, they would overwhelm the audiences. Yet, much of the literature cited is pre- (e.g., 2008) or around NCA4. Including more recent data would make the table more effective. Also, this table attempts to list three types of information: vulnerabilities, impacts, and adaptations. This is likely to be missed or misunderstood by broad audiences. Consider using icons or some other device to clearly distinguish these. The warning in the last sentence of the caption should add adaptations. Lastly, the marine transport section misses non-marine water transport, such as rivers and the Great Lakes. Examples are there, but the “marine” label is not inclusive. An alternative label is “waterborne.”

Comments on Literature Cited

The chapter is well sourced. However, the sentence that cites the White House fact sheet 13-4, Roadmaps to Net Zero by 2050, should include specific examples with additional citations.

Other Recommended Changes

The chapter does not address the connection between land-use decisions and transportation. For example, Key Message 13.1 does not explain that transportation is the largest source of GHG emissions because of auto-centric planning; and Key Message 13.2 does not mention how land-use and housing considerations are being integrated into transportation decisions to reduce GHG emissions (i.e., transit-oriented development). This discussion could be added briefly by cross-referencing relevant chapters.

This chapter is also an important opportunity to note the emerging evidence that CO₂ affects human cognition at levels observed in vehicles, including cars and airplanes. This has been missed in previous NCAs and even in IPCC AR6. Associated with this is transportation’s large contribution of CO₂, and higher concentrations in cities along arterials where minorities are disproportionately represented (Allen et al., 2018; Du et al., 2020; Karnauskas et al., 2020; Wang et al., 2021). A good place to mention this is in Key Message 13.3.

This chapter is notable in sharing focus reasonably equally between adaptation and mitigation. One thing to note, however, is that it does tend to mix marine with waterborne transport even while focusing on river transport and ports.

CHAPTER 14: AIR QUALITY

Summary

Overall, the chapter is a high-quality assessment of the knowledge base and covers several important topics. The key messages are well stated and adequately supported by the details in the chapter; however, confidence and likelihood levels are inconsistently used throughout the chapter and not sufficiently clarified or supported in the traceable accounts. The chapter is written at an appropriate technical level for the intended audiences, and the Committee particularly appreciates that the introduction clearly defines and provides context for concepts such as PM_{2.5}. However, there is an imbalance in the amount of attention for each topic. For example, it is not clear why certain topics received an independent key message (e.g., aeroallergens) and others did not (e.g., dust). While the chapter discusses how addressing climate change could improve air quality, more attention should be given to the petrochemical industry and the clean energy transition, which are very important to environmental justice. Furthermore, there are many broad statements throughout the chapter, and not enough emphasis on specific examples. For example, in either Key Message 14.2 or Key Message 14.3, there is an opportunity to discuss air filters and inequitable access to such health-protective measures. Additionally, while it is important to highlight negative impacts, the chapter could also expand on the positive examples of emission reduction efforts.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

Overall, the introduction does a good job highlighting the importance of air quality for human and ecosystem health. While the introduction appropriately introduces terminology that helps provide context for the rest of the chapter, the Committee suggests the chapter authors include a statement about anthropogenic sources of ozone and PM_{2.5} to better illustrate anthropogenic contributions to air pollution.

Comments on Key Messages, Supporting Information, and Traceable Accounts

Comments on Specific Key Message Language

Overall, the authors have developed well-articulated key messages around relevant themes. However, consistent with the recommendation in Chapter 2 of this report, the Committee suggests that key message titles be short, informative statements rather than topics, making them more effective and impactful, in particular for Key Messages 14.1 and 14.3. Key messages

consistently support statements with confidence levels, but many are missing likelihood statements; these should be added if there is quantitative evidence to support these messages.

Comments on Text Supporting the Key Messages

Key Message 14.1. Changes in Ozone and PM_{2.5}. The key message is clear, concise, and sufficiently supported by the text. The title of this key message could be modified to include the direction of change so that the title itself is more descriptive. The Committee suggests, however, that authors address how air quality consideration can significantly impact water resources, for example, that soot (black carbon particles) deposition onto snow or ice could drive more rapid snow/glacier melt. The chapter can do this succinctly and then cross-reference relevant chapters such as Chapter 8 (Ecosystems, Ecosystem Services, and Biodiversity), Chapter 9 (Coastal Effects), and Chapter 10 (Oceans and Marine Resources) to highlight the broad range of cascading impacts that soot can have.

Key Message 14.2. Protecting People from Wildfire Smoke. This section discusses the possibility of the risks of wildfires increasing in the future, partly due to climate change. The topic is very important; however, the chapter omits a discussion on emergency response measures, warnings, and related issues. There are several examples where a significant number of deaths were related to paucity of escape routes and lollipop development plans. For example, Paradise, California had only one route for escape, and the Oakland Hills fire in 1991 had limited escape routes.⁶ Additionally, the Committee suggests clearly articulating that wildfires occur naturally, but that climate change may increase the risk of fires in some ecosystems and cause associated poor air quality.

Key Message 14.3. Air Quality Environmental Justice. This section discusses inequitable exposures to poor air quality by race and socioeconomic status by source. The title of this key message could be revised to be a short, descriptive statement to strengthen the key message. Overall, the Committee commends the chapter authors on this well written section, and highlights that the specific case example of Houston, Texas, is particularly insightful. However, this section is framed with an urban focus and there is little attention to rural areas, so the Committee suggests expanding the rural discussion, or explaining why rural areas are not discussed significantly. Additionally, the last paragraph mentions that there are solutions for addressing air pollution equity (page 14-11, lines 3-4). It would be helpful to support this claim with an example.

Key Message 14.4. Impacts of Climate Change on Aeroallergens and Health. The section discusses how climate change will lead to a longer pollen season and increased pollen levels. The Committee suggests adding more about how mitigation of climate change could impact air quality and environmental justice concerns. In addition, as presented, it is unclear why two pollen maps are needed. Allergies are not as devastating as asthma, which receives little attention, or cancer, which is only briefly mentioned in Figure 14.5. The Committee suggests putting more emphasis on more serious health effects associated with degraded air quality. Finally, there is an imbalance in figures throughout the chapter. This key message has three figures associated with it while others only have one or two.

Key Message 14.5. Improving Air Quality While Addressing Climate Change. This section discusses how climate change actions will also improve air quality, but as written, it does

⁶ See <https://www.wildfirelessons.net/orphans/viewincident?DocumentKey=ead9d69e-300e-4881-80dc-7b5ac71a232b>.

not incorporate an equity analysis as was done in Key Message 14.3, which highlights that the distribution of benefits depends on the mitigation approach (e.g., previously cited Cushing et al. paper). The Committee suggests adding a couple of sentences to tie this concept back in. Additionally, Figure 14.10 and the associated discussion of co-benefits is important but not very accessible to broad audiences. The Committee suggests chapter authors rephrase this section discussion so that the message “save lives and money” is more effective. Furthermore, the statements on page 14-17 are difficult to discern as written. It would help clarify that while earlier technologies to reduce ground-level pollution were important, more recent shifts from coal to gas, wind, and solar have greater co-benefits of reducing GHGs and other pollutants.

Comments on Traceable Accounts

The Committee appreciates the emphasis on work since NCA4. However, the traceable accounts need more consistent citations. Some paragraphs are well cited, while others (e.g., those on page 14-20, “Description of Confidence” paragraphs) lack citations. Chapter authors should refer to the recommended framework for traceable accounts in Chapter 2 of this report to ensure consistency and credibility across NCA5.

Comments on Graphics and Boxes

Overall, the figures are effective and appropriate, but could use more detailed captions so that figures can stand alone. For example, the different models used in Figure 14.2. should be explained in the caption. Specifically, the caption should state that the values represent concentrations of important air pollutants and reference the models or papers. In Figure 14.3, the caption should include a statement about what the colors represent.

Figure 14.3, showing smoke across the United States on September 13, 2020, is very compelling, and it may be worth mentioning that this caused one of the worst air quality days in New York City a few days later. Figure 14.3 also does not show impacts to the US Caribbean.

The maps of Figure 14.5 are very important, but they are small and noisy, making them difficult to interpret. This figure would be more effective if simplified.

Figures 14.6 and 14.8 are not very effective and could be removed. Figure 14.9 offers important insights. Perhaps it could be redrawn so it could stand more powerfully on its own.

The traceable accounts on Figure 14.9 are appreciated. However, something similar needs to be built for Figure 14.1.

Comments on Equity and Justice

Equity and justice are embedded in the discussion effectively, though equity and justice-related issues could be framed more strongly in the introduction. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Other Recommended Changes

Dust is only mentioned once in the first key message, but the discussion is limited, and it is unclear if that is due to a lack of understanding about dust or because it is not very important.

The Committee suggests clarifying this lack of discussion and including an appropriate amount of text depending on its importance for air quality, compared with similar natural aerosols such as wildfire or pollen.

With the odds of wildfires increasing, COVID, and more widespread allergies, high-quality home air filters are now present in many homes across the west and are becoming more common in new heating, ventilation, and air conditioning (HVAC) installations. Home air filters have health, energy use, cost, and other implications, particularly for those with low income, and the Committee suggests that this adaptation be emphasized.

Additionally, the Committee suggests mentioning the improved indoor air quality associated with all-electric buildings. This is especially prevalent in the west where municipalities are moving away from methane hookups for new structures and are requiring new buildings to be all electric.⁷ However, electrification will require additional considerations.

CHAPTER 15: HUMAN HEALTH

Summary

Overall, this chapter captures many of the challenges and some of the opportunities presented by climate change for the United States population, and for vulnerable populations. However, the chapter does not yet fully meet the requirements of Section 106 of the GCRA due to omissions in content and its lack of documentation for the findings in a consistent, transparent, and credible way in the traceable accounts section. While the key messages of this chapter are generally well stated and supported by the detail in the supporting text, there are opportunities to use more accessible language and improve the graphics. In general, further cross-referencing of and by other chapters would help keep this chapter condensed and focused on human health and highlight the important connections between this chapter and other chapters (see discussion below).

This chapter has a few major omissions that are needed to fully contextualize the climate discussion, including (1) discussion of public health trends in the United States and the importance of environmental, economic, and social factors that create conditions that foster public health; (2) the limitations of the US medical system (made very clear by the COVID-19 pandemic); (3) discussion about how declining public health and a limited US medical system may exacerbate climate impacts to human health; (4) the implications of adaptation and mitigation decisions on human health; and (5) the contributions of the health sector to climate change. These major omissions should be included as part of existing content or perhaps as new key messages. Understanding that the chapter authors are constrained by word count limitations, the Committee makes recommendations where these omissions may be included throughout this chapter and where text may be scaled back to accommodate these suggested additions. Additionally, suggested literature for inclusion is referenced throughout this review.

⁷ See <https://www.bizjournals.com/sacramento/news/2021/06/02/sacramento-city-council-building-electrification.html>.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction to this chapter is concise; however, it could benefit from using more accessible language (e.g., repercussions versus impacts) and providing more context for the climate discussion. Specifically, the Committee suggests chapter authors add two short paragraphs to the introduction. First, the Committee suggests chapter authors begin the introduction with a short paragraph discussing “what is human health.” In this paragraph, the Committee suggests the chapter authors define human health broadly⁸ (IOM, 1988) to frame the climate impacts, adaptation, and mitigation discussion of the chapter. Following this paragraph, the Committee suggests adding a brief paragraph discussing public health trends in the United States and the importance of environmental, economic, and social factors that create conditions that foster public health; and the limitations of the United States medical system (Morris et al., 2021a,b).^{9,10,11,12,13} These topics provide necessary context for the rest of the discussion in Key Message 15.3 regarding the ability to adapt to climate impacts. The existing introduction paragraph would fit nicely after the paragraph discussing current public health trends and limitations of the US medical system. The introduction would benefit from more specifically referencing overburdened groups, such as persons with disabilities, children, sexual and gender minorities, BIPOC, the elderly, and those in communities that are and have been under-resourced and overburdened by health inequities and structural racism.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The key messages of this chapter generally reflect the current understanding about the observed and projected impacts of climate change to human health in the United States. The key messages generally reflect supporting evidence, but some statements within each message are missing confidence or likelihood ratings. The Committee suggests the authors add confidence and likelihood ratings (as applicable) to each statement or assertion. Specific instances where language is unclear are identified below. Each key message title should be a short, informative statement, consistent with the recommendation in Chapter 2 of this report, to help make the key messages more effective and impactful. The Committee makes recommendations where the major omissions discussed above may fit within existing key messages and where supporting text may be scaled back to accommodate these suggested additions.

⁸ World Health Organization (human health definition): <https://www.who.int/about/governance/constitution>.

⁹ See <https://www.tfah.org/article/nations-obesity-epidemic-is-growing-xx-states-have-adult-obesity-rates-above-35-percent-up-from-xx-states-last-year>.

¹⁰ Firearms are the leading cause of death: <https://www.nejm.org/doi/full/10.1056/nejmc2201761>.

¹¹ References that discuss occupational safety and health impacts: <https://www.weforum.org/agenda/2022/11/countries-compare-on-healthcare-expenditure-life-expectancy> and https://www.cdc.gov/nchs/pressroom/nchs_press_releases/2022/20220831.htm.

¹² References that discuss US medical system limitations: <https://www.theatlantic.com/ideas/archive/2022/06/nih-covid-vaccine-research-studies/661182> and <https://www.thenationshealth.org/content/51/8/1.1>.

¹³ Medical care expenditures growing: <https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/NHE-Fact-Sheet>.

Comments on Specific Key Message Language

Key Message 15.1. Climate Change is Harming Human Health

Climate change is already harming human physical, mental, and spiritual health through increasing frequency and intensity of extreme events, increasing cases of infectious and vector-borne diseases, and declines in food and water security. Climate-related hazards will continue to grow, increasing morbidity and mortality across all regions of the United States (*very likely, very high confidence*).

This key message title is rather broad and generic, though it is also direct and clear. Regarding the message content, the phrase “climate change is already harming ... health through ...” is not grammatically correct. The first sentence in the message should be rewritten to improve clarity. For instance, the content would be clearer if it read: “Climate change is currently harming human physical, mental, and spiritual health by causing an increase in the frequency and intensity of extreme events and the cases of infectious and vector-borne diseases as well as threatening food and water security.” Additionally, confidence and likelihood should be assigned to each assertion within the message.

Key Message 15.2 Climate Change Harms Community Health, and That Harm Is Exacerbated by Systemic Racism and Discrimination

Climate change continues to harm physical, mental, and community health in a number of ways, including by reducing access to quality food, water, and health care. Climate-related hazards disproportionately impact some communities and people, including communities that have been marginalized, low-wealth communities, women, older adults, those with chronic diseases, outdoor workers, and young children (*virtually certain, very high confidence*).

Suggested title: “Systemic Racism and Discrimination, Declining US Health, and Medical System Limitations Exacerbate Climate Change Impacts to Health.”

This key message title is very similar to Key Message 15.1. Climate change may exacerbate or create health inequities apart from those that exist due to systemic racism and discrimination. For this reason, the Committee suggests broadening this key message to also include discussion about how declining public health and a limited US medical system may exacerbate climate impacts to human health and to be more inclusive of climate related health inequities in addition to those exacerbated by systemic racism and discrimination. Additionally, the comma should not be included in the title sentence.

Regarding the message content, confidence and likelihood statements should be assigned to each assertion within the message. If this key message discusses how declining public health and a limited US medical system may exacerbate climate impacts to human health, the topic should be added into the content of the key message as well as the supporting text.

Key Message 15.3 Adaptation and Mitigation Actions Protect Human Health

Creating climate-resilient health systems, implementing adaptation measures, and mitigating greenhouse gas emissions can protect human health (*very likely, high confidence*).

Suggested key message revision: “The human health sector contributes to climate change by ____ (*Assign confidence and likelihood*). Adaptation efforts such as ____ protect human health by creating resilient health systems (*Assign confidence and likelihood*). Mitigation efforts can reduce health sector greenhouse gas emissions, which protect human health by ____ (*Assign confidence and likelihood*).”

This key message title and message content are overly broad and simplistic. It would be better to discuss adaptation and mitigation separately since they are two distinct actions with distinct impacts to health. The Committee also suggests expanding this key message to discuss, more specifically, the implications of adaptation and mitigation decisions on human health and the contributions of the health sector to climate change. If this is done, the Committee suggests assigning a distinct confidence and likelihood ratings to each claim.

Comments on Text Supporting Key Messages

Key Message 15.1. Climate Change Is Harming Human Health. Overall, the supporting text for this key message is comprehensive and occupies more space than the supporting text for Key Messages 15.2 and 15.3. The topics covered within this key message largely discuss climate-induced impacts to human health now and do not discuss projected impacts to human health into the future (e.g., 25 to 100 years into the future). If possible, the content should also reflect projected impacts into the future, as required by the GCRA.

The Committee suggests that the chapter authors revise the section on “Temperature Extremes” to include a discussion of how impacts will increase over time. This section would benefit from adding citations to literature documenting disparities in specific health outcomes rather than making vague statements about poor health outcomes (e.g., specify the adverse birth outcomes). Additionally, the section would benefit from cross-referencing Chapters 2 (Climate Trends) and 12 (Built Environment, Urban Systems, and Cities) to limit the amount of additional text. In the “Occupational Safety and Health Impacts” discussion, the Committee suggests the authors include emerging information that chronic heat stress and repeated dehydration can lead to kidney disease and even kidney failure in those working in high heat environments (Nerbass et al., 2017). The Committee also suggests authors mention that anticipated future climate heating may cause physical labor to increasingly move to nighttime work. In the “Compounding and Cascading Hazards” section, the Committee suggests the authors include a citation to the US Intelligence Community’s April 2022 Annual Threat Assessment where drought and famine, and climate change, are presented as complex threat multipliers in time (ODNI, 2022). This section would benefit from adding a citation to literature documenting disparities in specific health outcomes rather than making vague statements about poor health outcomes (e.g., specify the adverse birth outcomes). The “Drought” section should cross reference Chapter 4 (Water). Finally, the section on “Wildfires” would benefit from adding mention that firefighters who are heavily heat and smoke exposed are often low income or on occasions prisoners released to work and to be paid at a low rate.

In order to accommodate suggested additions to this key message the Committee notes the following areas where text could be reduced. The “Environmental Infectious Disease and Vector Borne Disease” section could be condensed, as it occupies more space than drought, wildfire, and food and water. The “Mental and Spiritual Health” section is quite long and should be condensed. Its summary comment about supporting “agency” among those suffering harm is an important takeaway, but this assertion should include a citation. Box 15.1 would fit more

appropriately under Key Message 15.2; the image does not need to be so large to be effective. The section on “Compounding and Cascading Hazards” is useful, though it could be condensed by using more specific language and only one very specific recent example instead of a few nonspecific examples.

Key Message 15.2. Climate Change Harms Community Health, and That Harm Is Exacerbated by Systemic Racism and Discrimination. The supporting text for this key message would benefit from omissions and additions. This chapter could benefit from citing Chapter 19 (Economics) in the discussion of this key message. For instance, this section should cite Key Message 19.1, which states that the economic impacts of climate change are projected to be distributed unequally across regions, industries, and socioeconomic groups. This section should also cite Figure 19.2, which documents that people with low income and persons of color are and will be powerfully harmed by climate, including educational attainment, damage to income, bankruptcy, and debt repayment.

The Committee suggests consistent usage of low-wealth, low-income, vulnerable populations, and other terms throughout the report and throughout this chapter. The “front lines of climate change” should also be defined; for those that are new to learning about climate change this term may not make sense.

Regarding content, some topics in the supporting text for this key message seem as though they do not fit within this section, and in other areas, this key message is lacking key context. Additionally, climate change may exacerbate or create health inequities apart from those that exist due to systemic racism and discrimination. For this reason, the Committee suggests broadening the Key Message and the Committee suggests additions to the supporting text below.

The “Community Health and Health Equity” section is lacking discussion about how declining public health in the United States and a limited US medical system may exacerbate climate impacts to human health. The Committee notes that this is the only chapter that can address the limitations of the US medical system, the condition of which will determine the ability to adapt and respond to climate impacts to human health. A few notable issues include that clinicians cannot devote the time and energy to issues as global as climate; public health impacts often result from cycles of panic and neglect; medical systems face system-wide workforce challenges; medical and public health systems are often political punching bags; and public health as a practice too often resides only in its own discipline and inadequately reaches out to other sectors like housing, banking, transportation, and agriculture, among others. This section is also lacking discussion of pervasive and increasing poverty in the United States that places more people at increased risk of climate impacts (Aladangady and Forde, 2021; Chetty et al., 2016; Cole et al., 2017; Oscilowicz et al., 2022; Rothstein, 2017; Taylor, 2019). Additionally, this section should mention the need to address mental health impacts of climate change that focus on communities rather than individuals, which will become more important as climate-driven disasters accelerate in scale and frequency. This approach may be even more necessary given the limitations of the US medical system. Finally, this section would benefit from adding a citation to literature documenting disparities in specific health outcomes rather than making vague statements about poor health outcomes (e.g., specify what the health risks are related to chemical and industrial disasters). These components that are omitted from this section are necessary to provide context to the rest of the discussion in this key message.

The supporting text does a great job covering various vulnerable populations, though there are omissions. For instance, children are not discussed. As mentioned above, Box 15.1 would fit more appropriately under this key message. The image should be made smaller to save

space. Persons with disabilities, the elderly, and those with chronic illnesses should also be included in this discussion for more broad coverage of those disproportionately impacted by climate impacts on health. In the “Tribal and Indigenous Peoples’ Health” section, the Committee suggests adding discussion of tribal health care system challenges, including of current, ongoing relocations in the United States (i.e., in Louisiana).

In the “Sexual and General Minority Health” section, the discussion about impoverishment does not explain how being impoverished makes a population more vulnerable to climate impacts. The Committee suggests providing more clarity in the language describing the relationship. Also, the discussion should explain differences compared to other impoverished groups. The text should describe why discriminatory beliefs held by faith-based first responders are good or bad, rather than forcing the reader to guess or infer what this means.

Regarding omissions, the inclusion of “Food and Water Security” is strange because most of the supporting text focuses on populations and systems, not topics. It begs the question why other topics covered in Key Message 15.1 are not also included in the supporting text for Key Message 15.2. Because food and water security are discussed in other chapters and the impacts of climate on food and water as they relate to health are discussed in Key Message 15.1, the Committee suggests removing this section (or moving the content up to Key Message 15.1).

Key Message 15.3. Adaptation and Mitigation Actions Protect Human Health. The text immediately following the key message assumes the audiences have preexisting knowledge. The Committee suggests defining mitigation and adaptation as they pertain to health. Proactive and continuing risk management should also be defined. It would be much clearer to discuss adaptation and mitigation separately since they are two distinct actions with distinct impacts to health. There is little to no discussion about mitigation in the supporting text for this key message. The Committee suggests adding pointed discussion throughout the existing sections where mitigation efforts are related to health outcomes.

The sections within this key message would benefit from headers that indicate what is discussed, rather than just a topic. For instance, rather than “Temperature Extremes,” perhaps use “Mitigating and Adapting to Extreme Temperatures.”

The supporting text for this key message is missing two key topics. Thus, the Committee suggests expanding this key message to discuss the implications of adaptation and mitigation decisions on human health and contributions of the health sector to climate change. The section on “Climate-Resilient Healthcare Systems” omits discussion about the implications of adaptation and mitigation decisions on human health, which should be discussed independently and not grouped together. Furthermore, the new content discussing the implications of adaptation and mitigation efforts on health should highlight the benefits these actions can bring to human health. The contributions of the health sector to climate change would fit nicely before the section titled “Climate Resilient Healthcare Systems.” This new section could cite Figure 19.5, which depicts the social cost of carbon from the health sector as equal to the sum of the social costs of carbon from energy, water, and coasts (Eckelman et al., 2020). This section also omits discussion about the need for more support for professional health workers (medical and public health) that work on climate issues (Frumppkin and Jackson, 2020).

The “Disease Surveillance,” “Extreme Temperatures,” and “Wildfires” sections should pointedly discuss whether the actions discussed are adaptation or mitigation efforts rather than leave the reader to guess. The “Disease Surveillance” section should discuss the limitations elucidated by the COVID-19 pandemic in US disease surveillance capabilities and cite the COVID-19 Focus Feature. The Committee suggests describing why there is a growing at-risk

population rather than stating it as a fact in the “Temperature Extremes” section. Finally, the “Temperature Extremes” section is quite long and could be condensed by focusing only on adaptation and mitigation and omitting the last paragraph, which discusses energy. The Committee is surprised air quality is not discussed as it is a key health benefit of mitigation efforts. If possible, the Committee suggests reducing the “Temperature Extremes” section and adding an “Air Quality” section that should heavily cross-reference Chapter 14 (Air Quality) and expand specifically on human health implications (Chen et al., 2021b; Diaz et al., 2021; Du et al., 2020; Karnauskus et al., 2019; Liu, 2012; Penney et al., 2009; Permentier et al., 2017; Satish et al., 2012; Schmidt, 2019; Scully et al., 2019; Seppanen et al., 1999; Snow et al., 2019; Wang et al., 2021; Zhang et al., 2017).

Comments on Traceable Accounts

The traceable accounts for this chapter do not cover each of the topic areas discussed, have no or limited citations, and do not describe the analytic process used to come to the confidence and likelihood ratings included in each key message. These are essential components to describe how chapter authors arrived at their confidence statements. The Committee’s full recommendation on traceable accounts can be found in Chapter 2 of this report.

Because this chapter’s traceable accounts section is lacking citations and explanation, the chapter does not identify and provide sufficient context for embedded content and does not yet reflect current scientific understanding. The traceable accounts should be revised to demonstrate *which* references support *each* confidence and likelihood statement under each key message.

Comments on Graphics and Boxes

The chapter’s graphics and boxes are generally effective and appropriate, though some may be better placed in different locations within the chapter (see above), and some could be better used. A conceptual model showing direct and indirect pathways through which climate change could impact health could be included, with emphasis where there is supporting evidence. A similar figure illustrating ways that specific mitigation or adaptation efforts can impact health would also be beneficial and could similarly note where evidence is strongest.

Figure 15.1 is about heat but focuses only on certain populations. The Committee suggests leading with the whole population and then offering an enlarged side diagram of the vulnerable groups.

Figure 15.2 is a United States map of increased impacts of climate sensitive diseases. Perhaps a cross reference to Chapters 4 (Water), 14 (Air Quality), 25 (Northern Great Plains), 26 (Southern Great Plains), and 28 (Southwest) would be appropriate. The reference to *Naegleria* (a warm water ameba associated with hot water) accounts for only two or three cases per year.

The Committee appreciates the geographic regional breakdown in Figure 15.2. The list/key could be color coded to match images on the map, and the colors in the figure should be explained. The icons are quite small; consider putting the key at the bottom to enlarge the figure. Schematic figures like Figure 15.2 should have captions with some indication of how/where the findings in the figure were generated. Listing universities tells the reader very little about where the data in this figure came from.

In Figure 15.3, the text is very big, the image and text could be smaller, and percentage numbers could stay the same.

Figure 15.4 mentions intergenerational equity and that topic should be mentioned in the paragraph that immediately precedes it.

Box 15.1 provides an interesting snapshot, but what worries people can change week to week. An example that looked at the progression over time could be more useful.

Comments on Equity and Justice

Equity and justice principles are adequately incorporated into the chapter and this chapter does a great job of dedicating a key message to the topic. Specific suggestions are included in discussions above (Key Message 15.2 and introduction). The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Literature Cited

The chapter accurately reflects the peer-reviewed scientific literature or other source information cited, with a particular focus on literature since NCA4. Specific literature recommended for inclusion has been described throughout this review.

Other Recommended Changes

This chapter does not discuss the emerging literature on CO₂ and human cognition, particularly the emerging literature on this impact at ambient levels of CO₂ observed in various settings and likely to be more widely observed in future (see citations provided above).

CHAPTER 16: TRIBES AND INDIGENOUS PEOPLES

Summary

Chapter 16 does not yet meet the requirements of Section 106 of the GCRA, but with the following specified additions and modifications should meet the requirements. At the outset, the chapter attempts to build on previous NCAs but omits context that is essential for readers and assumes a level of preexisting knowledge. The introduction should include an explanation about US recognition of tribal governments and the distinction between federally recognized and non-federally recognized tribes. Additionally, projections of climate impacts on Indigenous peoples and tribes are not discussed. This is a significant omission as projections are essential for any decision-making process. If this is key omission is reflected in the literature, then the research gap deserves attention. If not, chapter authors should add projections and supporting literature citations. Additionally, the key messages lack textual and organizational clarity, and are overly broad, making them inaccessible and ineffective to broad audiences. For example, the Committee cannot distinguish the importance and meaning of sovereignty, self-government, and self-determination in the main text, whereas the terms are defined more clearly in the traceable accounts section. Where relevant, cross-referencing other chapters would improve this chapter (e.g., where the chapter discusses COVID-19 it could cross reference the Focus on COVID-19 and Climate Change). Overall, the traceable accounts inconsistently substantiate the key findings of the chapter and should be revised to include the rationale for confidence and likelihood

statements. Citations of Indigenous-led research and Indigenous scholars are listed below for consideration.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The Committee suggests starting the introduction with a broader statement that puts into context who Indigenous people are and why there is a chapter specifically dedicated to Indigenous peoples and tribes. In the introduction, terms and concepts that might be unfamiliar to readers who do not work closely with tribes should be defined (e.g., sovereignty versus self-determination). Additionally, the introduction should explicitly discuss what knowledge can be found in previous NCAs and what topics will not be covered in the chapter. For example, the chapter authors could reference research on disruption of lives in coastal areas highlighted in NCA4.

The introduction omits discussion about the differences between federally and non-federally recognized tribes and why those differences exist. This omission assumes the reader has preexisting knowledge or has recently read NCA4, which does discuss this topic. The Committee suggests chapter authors add a discussion about the differences between federally and non-federally recognized tribes (see Appendix A for suggested language). Finally, the introduction text is broken up by large images, which makes it hard to read. The Committee suggests that larger groups of text are lumped together so that the information is easier to digest.

Comments on Key Messages, Supporting Information, and Traceable Accounts

In general, the key messages and supporting text could be written at a more appropriate technical level for broader audiences. The Committee notes that all the key messages in this chapter have confidence rankings assigned but not likelihood. The Committee encourages the chapter authors to ensure that the lack of likelihood rankings reflect a lack of quantitative information to support the key messages. If there is quantitative data available to support a finding in a key message, there should be a confidence and likelihood ranking. Additionally, consistent with the recommendation in Chapter 2 of this report, key message titles should be short informative statements so that they are more effective and impactful. Specific suggestions are provided below. Finally, in some cases, the key messages are overly broad, and therefore seem to overlap (e.g., Key Messages 16.2 and 16.3), leaving messages up to interpretation by readers. All three key messages would benefit from more precision and specificity.

Comments on Specific Key Message Language

Key Message 16.1. Climate Impacts and Risks for Tribes and Indigenous Communities

Climate change is already having negative effects on critical aspects of Indigenous peoples' well-being, including their livelihoods, health, nutrition, and cultural practices, as well as the ecological resilience of their territories. Indigenous peoples are responding

to these climate challenges in a number of ways, including by expanding use of renewable energy and working toward energy sovereignty (*very high confidence*).

Suggested title: “Climate Change Disrupts Livelihoods and Poses Risks to Economies and Health of Indigenous Communities.”

The Committee suggests adding a confidence ranking to the first sentence of this key message.

Key Message 16.2. Social Systems and Indigenous Resilience

By exercising their right to self-determination, Indigenous peoples can respond to climate change in ways that meet the needs and aspirations of their communities (*very high confidence*). However, their ability to exercise this right is often undermined by institutions and policies shaped by the legacies of settler colonialism (*very high confidence*). Expanded support from federal and state governments has the potential to uphold Indigenous self-determination to build climate resilience (*high confidence*).

Suggested title: “Indigenous Self-Determination Supports Climate Resilience.”

The Committee interpreted this key message in multiple ways. It was not clear whether the intent of this message was to discuss: Indigenous social systems, some of which seems to be covered in Key Message 16.1; how social systems are related to self-determination and supporting resilience; the importance of social systems within Indigenous societies, and the resilience of those systems; or how governmental assistance can be helpful or hurtful toward those Indigenous systems and resilience, depending on how the assistance is provided? In some ways, Key Message 16.2 is similar to Key Message 16.3. To avoid confusion, the Committee suggests the chapter authors clarify this key message and work to distinguish it from Key Message 16.3.

Key Message 16.3. Indigenous Leadership in Climate Change Response

Indigenous peoples lead numerous actions that respond to climate change (*high confidence*). Indigenous-led organizations, initiatives, and movements have demonstrated diverse strategies for climate adaptation and mitigation that are guided by Indigenous knowledge and values and Indigenous rights (*high confidence*).

Suggested title: “Promoting Indigenous Leadership Increases Climate Adaptation and Mitigation Efforts.”

Comments on Text Supporting the Key Messages

Key Message 16.1. Climate Impacts and Risks for Tribes and Indigenous Communities. The chapter authors valiantly attempt to include the term “self-determination” throughout the chapter, but sometimes the term seems out of context, or the way it is used is not grammatically correct. The term is a noun, not a verb, and it is the ability to exercise self-determination that is restricted.

The “Indigenous Energy” subsection on renewable energy discusses an Indigenous-led solution, and therefore may be better suited for Key Message 16.3.

The Committee suggests expanding the “Health Risks” section to discuss well-being, which includes the relationship between the environment (other noted values in the Status of Tribes and Climate Change [STACC] report) and mental or emotional health. Additionally, while the section on COVID-19 accurately captures the negative impacts of COVID-19 unique to Indigenous communities, it is very long and could be condensed. In the section “Relocation,” the Committee suggests adding text about US government-led Indigenous relocation efforts, not only those happening currently but also citing examples provided in previous national assessment discussions of efforts in Louisiana.

This key message could address projected impacts to better meet the requirements of Section 106 of the GCRA. If there is no literature that describes projected impacts to tribes, chapter authors should clearly discuss the research gap, either here in on the associated traceable accounts section.

Key Message 16.2. Social Systems and Indigenous Resilience. Key Message 16.2 would benefit from adding headers to the section to break up the long text and organizing the topics discussed within those headers. Adding headers will make the supporting text under this key message consistent in structure with other chapters.

Key Message 16.3. Indigenous Leadership in Climate Change Response. Like Key Message 16.2, Key Message 16.3 would benefit from adding headers to the section to break up the long text and organizing the topics discussed within those headers.

In the text supporting this key message, mitigation is discussed in tandem with adaptation and there are no specific examples given for tribal mitigation efforts. The Committee suggests including examples of mitigation efforts in the supporting text and differentiating the two terms.

Comments on Traceable Accounts

The purpose of traceable accounts is to describe how the authors arrived at their confidence and likelihood statements in each key message. The traceable accounts for this chapter are incredibly short and do not include many citations. The traceable accounts for each key message should include all the citations provided in the supporting text. Because the traceable accounts section is lacking citations, the chapter does not identify and provide sufficient context for the embedded content.

Each key message’s traceable account should make modifications based on the outline for traceable accounts provided in Chapter 2 of this report. Chapter authors should revise the traceable accounts to demonstrate *which* references support *each* confidence and likelihood statement under each key message. The traceable accounts should be written for more technical audiences (i.e., concise summaries of the literature) and chapter authors should include any technical details and/or key omissions not discussed in the supporting text.

Comments on Graphics and Boxes

Overall, the graphics communicate the various locations of tribal and Indigenous peoples. However, many figures are isolated from the text and their intent is confusing. As described in Chapter 2 of this report, figures should be self-contained and understandable by broad audiences. Figure captions should walk the reader through the purpose and main takeaways of the figure.

Figure 16.1 is not a helpful image as presently depicted. It is very busy, and it is hard to tell what purpose the figure serves besides to show that Indigenous peoples have overlapping

homelands across all regions of the United States and its territories. The Committee suggests making this figure an interactive feature online so a user can click on any county and see what Indigenous homelands the county overlaps. Additionally, “Federally Recognized Tribal Land” does not represent tribal lands that are held in fee rather than in trust (e.g., Alaska Native tribal lands now held by Native Corporations).

In Figure 16.2, “Federally Recognized Tribal Land” does not represent tribal lands that are held in fee rather than in trust (e.g., Alaska Native tribal lands now held by Native Corporations). The authors could consider showing the locations of all tribal and Indigenous peoples’ locations in this figure, but without the overlap of Figure 16.1. Additionally, authors may consider simplifying the figure to show federal land in one color and tribal land in another. The multiple colors and large scale of the map make it difficult to fully grasp the portrayed story. Alternatively, consider adding some “zoom-in” boxes to highlight some specific regions and interactions at the geographic interface of federal lands and tribal lands.

Figure 16.4 is a nice use of space and data, but the caption should explain what dot size represents.

In Figure 16.5, the images should be enlarged so the reader can better see boundaries of tribal lands. The figure caption should note that tribal lands assigned in treaties were often the least productive lands.

The example in Figure 16.6 may be better suited as a box with more details on the Hopi leadership example. If the figure is kept as is, the text should reference the Hopi leadership example and clarify if the project(s) are Hopi government led, a Community-Based Participatory Research project, Hopi scholars, or a Hopi organization.

Tables 16.1 and 16.2 raise more questions than answers. A sentence or two describing each table would be helpful either in the text or in the figure captions. The information could be conveyed better via text. The text could state: “Since 2011, the Bureau of Indian Affairs (BIA) has awarded 837 awards totaling more than \$61 million for tribal climate resilience through training and workshops, adaptation planning, ocean and coastal management planning, capacity building, youth engagement, and relocation, managed retreat or protection-in-place planning.” If the chapter authors retain the tables, the Committee makes the following suggested revisions: (1) in Table 16.1, the columns should be the same size so categories and number are in line with one another; (2) in Table 16.2, the caption should be updated to describe that awards are divided by regions; and (3) the caption and/or headers should answer the following questions: are awards higher in some regions because of higher submissions or greater awareness of funding opportunities? For each award, how many applicants were there? How many awards were offered by BIA? Should a BIA region map or explanation be included in the text? If the chapter authors are not prepared to provide explanations for such questions in the caption or main text, they may consider eliminating the tables.

Comments on Equity and Justice

The chapter generalizes to all US Tribes and Indigenous peoples when there is an expansive range in geography, wealth, self-determination, and cultural and environmental knowledge. Even within tribal organizations there is a range of knowledge. Therefore, the chapter could explain that the examples provided are mostly representative of the wealthier, well-known and recognized Tribes, Indigenous peoples, and Indigenous organizations. Although some of this is mentioned in the traceable accounts section, this context should also be provided

in the introduction and/or text supporting the key messages as it is important context for all audiences. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Literature Cited

There is a growing body of literature that discusses mental and emotional stress (or solistalgia) among Indigenous peoples and youth due to changes in their environment that could be included (e.g., Ford et al., 2020; Galway et al., 2019; Hatala et al., 2020; Lines and Jardine, 2019; Sanson et al., 2022; Spiegel et al., 2020).

Other Recommended Changes

The authors should consider contextualizing the discussion of “federally recognized tribal lands” and “non-federally recognized tribal lands” by describing why they are recognized and non-recognized. Many Indigenous lands are restricted by the various legal methods that were used to allocate lands. Additionally, the Committee suggests noting that most lands were not high quality and that “American Indian and Alaska Native” (AIAN) is a political not racial category. This discussion would fit nicely in the chapter introduction. See Appendix A for more details on this suggestion.

In addition, chapter authors could consider broadening the discussion in the chapter to low- and zero-carbon energy development, not just renewables, to ensure consistency with Chapters 5 (Energy Supply, Delivery, and Demand) and 32 (Mitigation).

Chapter authors may consider the following additional references: Billiot et al. (2019a,b), Burns et al. (2021), and Johnson et al. (2022).

CHAPTER 17: CLIMATE EFFECTS ON US INTERNATIONAL INTERESTS

Summary

Overall, this chapter is well-stated, though there are opportunities, described below, to expand some of the discussion to in order to better support the charge of the chapter to focus on climate effects on US international interests. For the most part, this chapter meets the requirements of Section 106 of the GCRA. However, projections that extend 100 years in the future are nearly absent from this chapter as a side effect of the historical tendency for the scientific community to concentrate its attention up to the end of the current century rather than a fixed duration in the future.

The key messages in the chapter are clearly stated and generally supported by the detail and sourcing provided within the chapter. The discussion of key messages prioritizes newer literature (since NCA4) and generally includes citations after each assertion.

Overall, the chapter is written at the appropriate technical level. The chapter does contain some technical language that may be difficult for some audiences to follow, and specific suggestions are provided to maintain clarity and accuracy. Chapter authors may consider using the first sentence to introduce the purpose of the chapter, as done in the traceable accounts section.

There are issues with geopolitical and climate jargon throughout. Examples include “nexus approaches,” “enabling environments,” “geostrategic,” “net zero,” and others. Authors should be careful to use terminology that is accessible to broad audiences. In general, the chapter authors should reduce the use of jargon and define terms in the glossary or in the chapter where they are used.

Additionally, the chapter omits important international treaties and dynamics, discussed below. The chapter focuses on impacts and adaptation with a more limited discussion of mitigation (except for Table 17.1). Added emphasis on mitigation would be appropriate given the growth of global GHG emissions outside the United States with implications for the United States. The Committee suggests the authors consider whether developments relative to international treaties as well as those relative to GHG mitigation warrant greater consideration within one of the existing key messages.

There is also little mention of the regional differences across future climate projections and too much focus on global metrics. Climate change will affect regions in different ways partly due to heterogeneous changes in precipitation and temperature patterns (e.g., currently fertile regions may become less fertile and vice versa). Such redistributions of resources may contribute to geopolitical instability, but these issues are not included. The authors could do a better job citing the scientific literature to highlight specific at-risk regions and how they map onto US interests. Arctic warming and the loss of Arctic sea ice has clear geopolitical implications for energy and trade and more references are needed to support this point.

The representation of Chapter 17 (Climate Effects on US International Interests) in Chapter 1 (Overview) is not evenly balanced. The word “international” is only mentioned in passing, and Chapter 1 (Overview) only mentions one key message from this chapter. The Committee is concerned that a single report that is not fully supported by other literature (discussed below) about how much global economic output could be affected by climate change is given focus. Chapter 19 (Economics) should guide findings in this domain.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The Committee appreciates how the introduction directly references the key messages, providing a roadmap to the chapter. This model could be adopted for other chapter introductions. Overall, the introduction does an excellent job of succinctly summarizing the key messages, except that page 17-3, lines 19-23, does not cite any literature, in contrast to the highly credible and persuasive sources provided in the rest of the section.

There is a good discussion of international climate services (Box 17.1), but it lacks any specific examples. The Committee suggests that NCA5 authors reconsider the relative importance of this box compared to other messages that are not present. While it is interesting, it is not critical and could be removed to make space for a discussion on migration, which is a more important topic. Additionally, as written in the draft NCA5 report, Box 17.1 could also be interpreted as policy prescriptive.

Comments on Key Messages, Supporting Information, and Traceable Accounts

With the exceptions noted below, the key messages in this chapter reflect the current understanding of observed and projected impacts of climate change internationally that affect key interests of the United States. The key messages are written in a consistent and appropriate way and reflect supporting evidence well. However, the key message titles would be more impact as short, informative statements (see below for suggestions). Key Message 17.1 includes confidence without likelihood in one statement while all other statements in the other key messages provide both. Descriptions of the evidence base in the traceable accounts section does not include citations across all four key messages.

Comments on Specific Key Message Language**Key Message 17.1. Interdependent, Systemic Climate-Related Risks**

In a globally connected world, climate impacts on US interests are multifaceted, interconnected, and frequently exacerbated by social unrest and environmental degradation (*likely, high confidence*). The interdependent nature of global economic and natural systems, and the projected intensification of climate change, are expected to increase the scale and speed of these impacts (*likely, high confidence*). Emerging systems- and scenarios- based approaches to integrative planning, as well as improved climate services, can help alleviate these challenges (*high confidence*).

Suggested title: “The US Faces Increased Interdependent, Systemic Climate-Related International Risks.”

The text of Key Message 17.1 is not well phrased, and chapter authors should consider revising the statements. The first two sentences conflate several concepts and do not transmit a clear message. The ideas could be more simply stated: “The world is interconnected and events in one part of the world can affect US interests.” The second sentence does not note whether the increased speed and scope of climate change impacts is the result of the world becoming more interconnected or of increased frequency and severity of climate impacts. The key message could more clearly state cause and effect. The last sentence of the message could be perceived as policy prescriptive because it appears to recommend greater use of climate services. This key message uses confidence likelihood metrics consistently except for the final sentence, which only cites confidence. The Committee questions the high confidence level ascribed to the final sentence, and appropriate supporting evidence should be provided in the traceable account.

Key Message 17.2. National Security

Climate change can contribute to political and social instability and, in some instances, to conflict (*likely, high confidence*). It impacts the operations and missions of defense, diplomacy, and development agencies critical to US national security (*very likely, high confidence*). The US government, bilaterally and in collaboration with international partners, is increasingly addressing these implications through a range of diplomatic, development, and defense responses (*very likely, high confidence*).

Suggested title: “Destabilization of Other Countries by Climate Change Affects US National Security.”

The text of Key Message 17.2 is carefully crafted, clearly stated, and accurately reflects the complicated state of the science on climate change and conflict. It is very similar to a key message in NCA4. Since the US military, diplomacy, and foreign assistance are already addressing the effects of climate change (e.g., planning for climate change impacts, providing relief for extreme events which have been made more severe by climate change), the confidence level for the final sentence should be *virtually certain*.

Key Message 17.3. Economics, Trade, and Investment

Climate change is increasingly impacting global economic growth, trade, and investment, with significant implications for US economic interests (*very likely, high confidence*). Global mitigation and adaptation responses by governments and businesses will likewise significantly impact US economic interests, presenting both risks and potential opportunities for the US economy (*likely, high confidence*). Enabling environments, including regulation, incentives, financial support, and public-private partnerships, will influence the degree to which climate responses negatively or positively impact US economic, trade, and finance interests (*likely, high confidence*).

Suggested title: “Disruption of Economies, Trade, and Investment Outside the United States by Climate Change Creates Challenges and Opportunities.”

In the text of Key Message 17.3, the Committee considers the confidence likelihood levels ascribed to the first sentence on climate change affecting economic impacts to be too high and not supported by the traceable account. A key issue is what is meant by “significant.” If this refers to absolute dollars, then the cost of weather and climate extremes is clearly increasing. However, another approach is to examine losses as a share of global economic output. Alternatively, it is unclear if this statement is meant more about how international climate change mitigation, rather than impacts or adaptation, is affecting the US economy. Additionally, the phrase “Enabling environments,” has a specific meaning¹⁴ that may not be widely known, yet it is used in Key Message 17.3. This term should be defined somewhere in the text and should not be used in a key message.

Key Message 17.4. Sustainable Development

Climate change is undermining the world’s ability to develop sustainably, reversing development gains, and exacerbating inequities (*very likely, high confidence*). Climate finance is not keeping pace with current needs, even though proactive investments in climate-resilient development are more cost-effective than reacting to the impacts of climate (*likely, high confidence*). Climate-resilient development actions look to implement greenhouse gas mitigation and adaptation responses for the benefit of all and can identify opportunities to leapfrog development hurdles on a path toward sustainability (*likely, medium confidence*). Knowledge of effectiveness of mitigation and adaptation responses is sufficient to take action (*likely, medium confidence*). Evidence points to best practices, grounded in equity and justice considerations, and the principles of locally led and co-development that underpin pathways to strengthen the feasibility of achieving sustainable, climate-resilience development at scale (*likely, medium confidence*).

¹⁴ See <http://uis.unesco.org/en/glossary-term/enabling-environment>.

Suggested title: “Climate Change Challenges the Sustainable Development Paradigm.”

While the language of this key message is clear and simple, it is very long, particularly compared to other key messages. Chapter authors could consider splitting up this key message to be more easily digestible.

The first sentence of Key Message 17.4 discusses an emerging area of research, so the confidence levels may not be as high as stated, and it would be appropriate to note the need for more research in the text. For example, there are other contributing factors such as COVID-19 and the war in Ukraine that make it difficult to tease out causation.

Comments on Text Supporting the Key Messages

Key Message 17.1. Interdependent, Systemic Climate-Related Risks. The text supporting Key Message 17.1 is well written and notes interconnections among issues and approaches such as food imports, decision making that recognizes interdependencies, incorporating adaptation and mitigation early in systems-level planning, vertical and horizontal integration of responses, scenario development, and participatory approaches. The Committee suggests the authors consider noting in the traceable accounts for this key message that more experience and testing of such approaches is needed. On the other hand, the discussion of this key message does not mention population growth as a compounding risk, a topic with a rich textual basis.

The text mentions cascading tipping points, compounding risks, and the scale of impacts as areas of concern. It provides breadbasket failures as an example and specifically cites the Ukraine war as an example of compound and cascading impacts. The Committee appreciates these as examples of compound and cascading impacts, but the connection to climate change is not clearly stated. The Focus on Compound and Complex Events should also be cross-referenced.

This section could reduce the number of examples of international impacts to save space and put more emphasis on implications of these impacts on US interests. The chapter can reference IPCC (2022a), which addresses the impacts mentioned in this key message, among others. Such a reference would save space to address comments about topics insufficiently addressed in the chapter.

Key Message 17.2. National Security. In Table 17.1, the authors are encouraged to consider how much confidence there is in the projections presented. Table 17.1 and Figure 17.2 rely upon single sources, which suggests incomplete integration of the existing literature. The data appear to show dramatic difference in risk levels and the findings appear to be somewhat speculative. The authors should note whether there is any assessment of baseline conditions and what scenario the information is based on. It is surprising that the study finds such dramatic changes in a few decades.

Topics that are not covered in the discussion of this key message include the discontinuity of approaches to foreign policy as US administrations change. The discussion infers trends in approaches of the US government presumably based on one year of literature concerning actions of the current administration, which is not sufficient for inferring trends. The discussion does not include literature that discusses how international impacts and responses to those impacts shape US domestic policy. Another missing topic is the implications of declining fossil fuel use in major industrial economies for the international order and US interests, as well as the emergence of the United States as a major fossil fuel exporting country. There is little

mention of stranded assets and the implications of that as an emerging policy issue. This compounds the lack of discussion of research on the role of major international fossil fuel producers in the energy transition. Three topics are discussed but lack any connection to real cases without any citation of examples: disruption of supply chains, collaborative multilateral forums, and concept of operations.

Key Message 17.3. Economics, Trade, and Investment. Of the four key messages in this chapter, the Committee suggests the text supporting this key message requires the most attention. In general, it presents an overly optimistic interpretation of scant data and assignments of significance without support. The Committee suggests avoiding phrases such as “increasing priority,” “increasingly view,” “significantly increased,” and “increasingly focused” unless corresponding evidence can be provided.

The Committee questions if it is appropriate for this chapter to attempt to summarize global economic impacts, particularly based on just one study. This topic was not covered in NCA4, and IPCC adequately covers that topic. Furthermore, there is much literature estimating potential impacts of climate change to global products. The Swiss Re study (which is incorrectly cited in the citations) is an outlier and uses questionable methods to estimate losses (i.e., it addresses uncertainties by multiplying quantitative estimated impacts by 10 with no justification of that multiplier). The Committee suggests the chapter address the consequences of projected decreases in global GDP for the United States.

The statement that growing economic losses from climate change exceed economic growth and increase in assets is misleading (page 17-12). Pielke (2021) argues the increase is entirely explained by economic growth and Botzen et al. (2021) offers a different explanation of the data that does not rule out a climate signal. A more accurate reflection of the literature would be to point out that there is not a consensus in the literature on whether a clear climate change signal has emerged in global economic damage data.

Significant gaps in the text include discussion of the growing use of carbon offsets by several orders of magnitude since NCA4 and the implications of the published guidelines for Article 6 of the Paris Agreement for offset use.

The discussion also lacks a documented assessment of the failure to raise the international finance needed to address climate change. It would be appropriate to discuss the implications of countries raising funds to address only one-third of their stated need. The only metric given is GDP loss and there is no discussion of the criticisms of GDP as a metric for development.

Key Message 17.4. Sustainable Development. In the text supporting Key Message 17.4, the literature cited supports the assertion about projected impacts on sustainable development goals. However, the discussion of this key message fails to note that world development suffered losses during the COVID-19 crisis and implications due to the Ukraine war, although the impacts of the Ukraine war are mentioned previously. The text also does not address baseline development trends, which are a critical factor affecting the vulnerability of developing countries to climate change.

The text supporting this key message appropriately mentions that financing is far short of needs. However, it does not present literature with projections of how this will likely play out, leaving audiences with the implicit assumption that this will be corrected. Examples of the challenges not addressed include military challenges, supply chain disruptions, instability, displacement, and food shortages.

The text suggests that one solution to hunger is redirection of development funds to food purchases but fails to connect the dots to further impediments and risks to future development due to the resulting lack of funds.

This key message is general and does not focus on how sustainable development impacts will affect US interests. For example, there are likely implications for national security (Key Message 17.2) and foreign assistance. The latter topic is discussed as a global matter instead of focusing on specific implications for the United States. The text mentions IPCC AR6 but could rely on it more and remove citations already sufficiently discussed there. Lastly, as presented, it is not clear that Table 17.2 is necessary to support this key message.

Comments on Traceable Accounts

Generally, the discussion of traceable accounts is reasonable. The traceable accounts are concise, but hardly ever explain how the authors arrive at a confidence assessment based on the strength of evidence and agreement of independent sources, which is the task of the traceable accounts section. The descriptions of the evidence base in the traceable accounts section do not include any citations, which should be rectified.

There is no discussion in the traceable account for Key Message 17.3 about the literature on global economic impacts of climate change. Since the Committee suggests that the chapter not attempt to summarize the literature on global economic impacts, then having no discussion would be appropriate. If the chapter is going to discuss global economic impacts, then it could better utilize IPCC and cite studies such as Diffenbaugh and Burke (2019) and Tol (2018).

Comments on Graphics and Boxes

The figures are designed well but, the captions should be self-contained. The captions should tell audiences how to read the figure and the message of the figure.

Figure 17.1 is clear and useful. The Committee suggests changing “economic disruption” to “economic losses” to make the language consistent with the right side of Figure 17.1 and avoid use of the more inflammatory term “disruption.”

Figure 17.2 is effective but relies on a single source and is not integrated into the text discussion well.

Table 17.1 is an effective table and the demonstration of change over time is helpful for an assessment. Consider adding colors to the boxes (i.e., green-yellow-red scale) so audiences can easily see patterns. Additionally, some specific examples or photos to make this table a more compelling story. Also consider moving the box to within one of the key message sections.

Comments on Equity and Justice

Equity and justice issues are well integrated in the introduction and throughout the chapter. The Committee suggests that authors ensure that assertions concerning equity and justice are documented as fully and carefully as with other scientific assertions (see Appendix A for specific examples). Well-documented statements offer substantial support for addressing the concerns of the communities involved. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Data and Analyses

The chapter relies on data analyses reported in the existing literature and other sources. The chapter authors do an acceptable job applying the data from the existing literature in a consistent, transparent, and credible manner.

When discussing data availability, there is little note of the rise in application and availability of satellite data. There is a particularly unfortunate gap regarding GHG measurements and related developments for source attribution studies. This is an important topic when considering enforcement of international agreements and tracking the impacts of international funding for mitigation efforts (e.g., NASEM, 2022b).

Comments on Literature Cited

In general, citations refer to literature that post-dates NCA4. Exceptions are not problematic.

Other Recommended Changes

The chapter fails to cite treaties and commitments—a key element of human social systems—outside the normal climate suspects (e.g., United Nations Framework Convention on Climate Change, Paris Agreement, Sendai, Sustainable Development Goals), so there is a lack of analysis of how climate change may affect those international commitments. The rethinking of the Energy Charter Treaty is a perfect example to discuss here. The implications of the Jones Act are also a good target for discussion regarding disaster recovery.

The chapter also does not note that the United States left and reentered the Paris Accord and fails to mention developments on Article 6 of that Accord and its import for international carbon markets and the use of offsets in and by US interests. It misses recent impacts of climate change (e.g., drought in the western United States) on transboundary water agreements with Canada and Mexico. New developments on border adjustments for carbon content in traded goods such as the European Carbon Border Adjustment Mechanism and the relation to the Global Agreement on Trade and Tariffs, and in transboundary pollution treaties such as the Basel Convention deserve mention.

In general, discussion of population growth and growth differentials between countries and the implication of that growth for climate change, both in terms of mitigation and adaptation as well as internal and cross-border displacement, are not addressed, and the relevant literature is left unexplored.

There is little discussion of migration, a very important risk from climate change. Chapter 19 (Economics) and Chapter 28 (Southwest) discuss migration and could be cross-referenced. The matter of whether climate change can or will spur more migration, particularly to the United States, has received increased attention in the literature. NCA4 was equivocal on the role of climate change and migration, finding that the information base was limited. An important matter is whether the new literature supports a different finding. Some examples of recent literature include de Koning and Filatova (2020) and Wrathall et al. (2019).

At minimum, references should be added to the statement concerning the Arctic (page 17-9, lines 12-14). If none exist, this should be noted as a research gap in the traceable accounts. In this context, discussion of the impact of higher temperatures on permafrost and impact on

transport and oil and gas production and transport, buildings, and water would help. The impact of climate change on US military infrastructure located abroad is not explicitly mentioned in the section on national security (Key Message 17.2). SLR, drought, wildfire, and other hazards pose risks for US military infrastructure on US soil and abroad, and the impact on military readiness should be mentioned. SLR as a systemic economic risk to international order is not mentioned.

Chapter authors are cautioned to take care in discussing risks, hazards, and impacts. These are mixed up in some places and should be defined when used. Consider replacing the phrase “risks impact” with “hazards impact.” Other concerns include imprecise use of the term “significant,” which is an overused and undefined term; confusion of climate and climate change; confusion of climate impacts and climate change impacts; failure to provide concrete examples except as implied by citation; and incorporation of neologisms such as “climate intensification” and “cascading risks.”

CHAPTER 18: SECTOR INTERACTIONS, MULTIPLE STRESSORS, AND COMPLEX SYSTEMS

Summary

The Committee commends the NCA5 authors for including this chapter, and attempting to communicate complex interactions and multiple stressors, because understanding the relationship between complex systems and vulnerability to climate change is critical to understanding risks and decision making. Additionally, the Committee appreciates the discussion of governance and decision making, multiple types of knowledge, interdisciplinary and transdisciplinary research, and intersectional identities. However, this chapter misses an opportunity to effectively communicate how complex systems are interrelated, and how to think about complexities in an integrated context relevant to climate change impacts.

As written, this chapter does not achieve its objective to integrate information, and instead provides a list of issues and contexts. As a result, this chapter does not yet meet the requirements of Section 106 of the GCRA. After making the recommended changes below, the Committee believes this chapter will meet those requirements. The key messages do not satisfy the criteria, outlined in Chapter 2 of this report, for effective key messages. The information is not presented in a logical, consistent, or credible way. The most important information that should be included in each key message is instead buried in the supporting text. Additionally, the supporting text does not clearly connect back to the key messages, and often, individual paragraphs appear to be written as disconnected ideas. Readers would expect this chapter in particular to show inherent connections between the topics discussed. The Committee suggests chapter authors tackle specific concepts within each key message, improve cohesion between paragraphs and key messages, assure supporting text relates back to each key message, and integrate this chapter with other chapters in the report. Some cross reference opportunities the Committee noticed include: add Chapter 4 (Water) and Chapter 28 (Southwest) references to the western United States discussion in Box 18.1; add references to Focus on Western Wildfires and Focus on COVID-19 and Climate Change in Box 18.2. Global change is not mentioned in this chapter, and it may be appropriate to discuss the complex interactions between climate change and climate change, as is done, for example, in Chapters 6 (Land Cover and Land-Use Change), 8 (Ecosystems, Ecosystem Services, and Biodiversity), and 10 (Oceans and Marine Resources).

There is also an opportunity to include interactions between climate change, climate variability, and impacts, such as on the agriculture sector. In some cases, climate change may result in changes in variability; in other cases, such as the western US megadrought, climate change is exacerbating variability. Adding discussion of these complex issues and impacts may make the chapter less academic and more appropriate for broad, practitioner audiences.

In addition, the text is written at a technical level that is inaccessible to the broadest possible audiences, as defined in Chapter 2 of this report, and contains a significant amount of jargon that makes important information difficult to untangle.

Finally, the figures in this chapter are well done, and are a valuable tool for illustrating complexities and uncertainties in an accessible format. The Committee suggests better integrating the figures into the text to help clarify some of the complexities discussed.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction does not provide the necessary background or context to make it effective. “Complex systems” is an incredibly broad topic, and the Committee suggests chapter authors use the introduction to provide a roadmap to the chapter, including a brief statement describing what will be covered in the chapter, and what will not be covered, and why. Noticeably, the introduction is not written at a technical level that is appropriate for a broad audience. There is a lot of jargon, and the Committee suggests using language that is more direct and clearer. For clarity, “complex systems” and “multiple stressors,” including “non-climate stressors,” should be defined from the outset, with relevant examples referring to the other chapters in the NCA5.

The chapter may create confusion as written because each key message is discussing different topics; they do not seem integrated as written. For instance, key message 18.2 discusses compounding impacts and the limitations of models as well as vulnerable populations. Key message 18.3 introduces completely new topics: competing perspectives, uncertainties, relevant knowledge, outcomes, and inform research needs, and knowledge creation. These topics do not appear connected at all. The Committee suggests revising the key messages to build upon one another, to relate to one another, and to be more cabined within one subtopic of complex systems. Each key message, as presently written, takes on many different topics, which makes it difficult to come away with a takeaway.

The first paragraph of the introduction could be expanded on slightly to provide more context for readers, including explicitly connecting the rest of the topics in this report (e.g., physical science, national and regional topics) to the key messages of this chapter (see Chapter 2 of this report). Along these lines, the chapter has next to no references to other chapters despite being the chapter on intersectional issues. The last paragraph of the introduction is unclear. The Committee suggests chapter authors revise the last paragraph of the introduction to use more specific language. For instance, the first sentence could be modified to say: “There is growing evidence *that shows using a complex-systems analysis can support and bolster* research and decision making.” The second sentence uses the phrase “new results”; however, it is unclear what new results chapter authors are referring to. The Committee also suggests that chapter authors cross-reference to other NCA5 chapters to illustrate the importance of using a complex-systems analysis/framework.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The key messages throughout this chapter use a lot of technical language and jargon, and the Committee suggests simplifying the language and replacing jargon or defining technical words in line if they cannot be replaced. Additionally, as outlined in Chapter 2 of this report, the Committee recommends rephrasing titles of key messages so that they are short, informative statements, thereby making them more effective and impactful. It is also essential that chapter authors provide confidence and/or likelihood levels for each assertion in the key message to give important context to the audiences. Many statements in the key messages in this chapter are not supported by confidence/likelihood levels.

Comments on Specific Key Message Language**Key Message 18.1. Characteristics of Complex Human–Natural Systems**

Interconnected networks of people, infrastructure, commodities, goods, and services are increasingly vulnerable to climate risks and compounding stressors. The vulnerabilities in these networks, and their effects on human–natural systems, are dynamic and complex. Decision-makers seeking to reduce climate change risks will have to navigate diverse, sometimes competing objectives and perspectives across many actors, institutions, and geographic scales while reconciling deep uncertainties and limits to predictability (*high confidence*).

The title of this key message should be reworded to be a more informative, short statement. Additionally, a confidence level is only provided for the last statement in the key message, but it should be provided for every statement in the key message. As written, the last sentence of the key message stands out as being the most impactful, and the Committee suggests rearranging this key message to make this the first sentence.

Key Message 18.2. Distribution of Vulnerability and Impacts in Complex Systems

Climate impacts exacerbate the vulnerability of already-disadvantaged groups, especially given compounding and cascading effects among nature, societies, and the built environment. Complex-systems models and decision-making tools do not yet account for the role of social dynamics in data collection and availability, governance strategies, and vulnerabilities relevant to climate change. Decisions based mostly on readily available data that can be easily incorporated into analyses may disadvantage particular groups (*high confidence*).

The key message title should be rephrased to be a short, informative statement, synthesizing the supporting text. Additionally, the key message includes three sentences that have a single “high confidence” assigned to them. It is not clear whether this confidence level is specific to each individual claim. The key message should be revised to assign confidence and, if applicable, likelihood to each claim.

This key message seems to tackle too much. In fact, the first sentence of this key message tries to say so much that the sentence loses clarity. It is hard to track what the intended key message actually is. Is it that vulnerabilities are compounded due to complex interactions of

climate impacts? Is it that social dynamics are not accurately modeled in data? Or is it that models do not account for the compounding impacts of climate change?

The first sentence uses the phrase “compounding and cascading effects among nature, societies, and the built environment,” which could be described using simpler words to improve understanding by a broad audience base. The first sentence also omits discussion of how climate impacts also create vulnerabilities for those who were previously not vulnerable to climate impacts. It is unclear why social dynamics are discussed in the third sentence since the key message previously discussed compounding climate impacts to nature, society, and built environments. It is similarly unclear what the chapter authors are trying to convey in the last sentence.

Suggested revised key message: “Climate change causes impacts to nature, societies, and built environments that exacerbate vulnerabilities of already-disadvantaged groups and create vulnerabilities for people who were previously not vulnerable to climate impacts. Often these impacts interact and build upon one another, which can increase the overall severity of the impacts. Complex models and decision-making tools do not yet account for the interactions between climate impacts or for vulnerabilities, which limits the accuracy of models that inform decision making.”

Key Message 18.3. Actionable Knowledge for Complex-Systems Decision-Making

Responding effectively to climate change benefits from approaches suited to complex systems and matched to specific contexts and needs (*high confidence*). Participatory and collaborative approaches can help decision-makers accommodate competing perspectives, address uncertainties, increase the use of relevant knowledge, improve outcomes, and inform research needs and knowledge creation (*medium confidence*).

The title of this key message should be rephrased to convey a meaningful message, rather than a heading. As for the message, the Committee suggests rewriting this key message, and before doing so, clearly deciding on the scope and message trying to be conveyed. A rewritten key message may want to omit the first sentence entirely and break apart the second sentence. As written, this key message is rather abstract. It would greatly benefit from using clearer, more specific, and grammatically correct language. For instance, as written now, there is no noun in the first sentence, which creates a great deal of confusion. The second sentence of the key message includes a list with many parts. The list is also confusing because the list seemingly has nothing to do with the previous key message. It is also unclear if each claim in the list is being assigned medium confidence—this should be clarified by including confidence and, if applicable, likelihood statements for each claim. Additionally, this key message includes a lot of jargon, such as “transdisciplinary” and “co-production.” The Committee suggests either rephrasing these statements to include definitions of these terms or replacing the terms with clearer language. The text supporting this key message could better connect to and cross-reference Chapters 19 (Economics) and 31 (Adaptation).

Key Message 18.4. Knowledge Gaps and Principles for Managing Complex Systems

Climate change presents challenges for different levels of government, the private sector, and civil society. Current governance entities are often unable to resolve conflicts posed by the wide-ranging interactions and complexities of climate change and more localized

compounding stressors (*high confidence*). Local and regional governments have experimented with alternative institutional arrangements, funding mechanisms, and decision coordination, but thus far there is only preliminary evidence for their effectiveness (*low confidence*). These and other innovations developed for climate mitigation and adaptation (and their interactions) may well present opportunities for replication and broader successes in other locations and different local contexts (*medium confidence*).

Suggested title: “Climate Change Presents Challenges for Different Levels of Government, the Private Sector, and Civil Society.”

The key message title does not convey meaningful information. The first sentence of the key message would make a more appropriate title: “Climate change presents challenges for different levels of government, the private sector, and civil society.” This key message is quite wordy, but it is clearer than the other key messages. The Committee suggests removing unneeded additional words (see above). Additionally, the Committee suggests emphasizing that the “other innovations” in the last statement of the key message may present broader opportunities. However, “other innovations” is vague, and could be sharpened to convey more meaningful information.

Suggested revised key message: “Governance entities are often unable to resolve conflicts presented by the wide-ranging interactions of climate change (*high confidence*). Local and regional governments have experimented with alternative institutional arrangements, funding mechanisms, and decision coordination, but there is only preliminary evidence for their effectiveness (*low confidence*). These efforts and other innovations developed for climate mitigation and adaptation and their interactions may present opportunities for replication and broader successes (*medium confidence*).”

Comments on Text Supporting the Key Messages

For each section of supporting text under each key message, the Committee suggests the chapter authors create sub-headers to group the text into meaningful sections of text. This change would make the chapter consistent with other chapters in the report and will make the text easier to review for broad audiences.

Key Message 18.1. Characteristics of Complex Human–Natural Systems. In addition to adding sub-headers, this section would benefit from either moving Box 18.1 down to a different key message or including related information in the supporting text under Key Message 18.1. As written, the box does not seem to fit well with the information in this section. In place of Box 18.1, additional examples of interdependencies could be included.

Additionally, it is not clear in the text if the increasing vulnerability is a result of increasing linkages, climate change, or both. The Mora et al. (2018) reference, for example, points to the magnitude of climate change as increasing vulnerability.

Key Message 18.2. Distribution of Vulnerability and Impacts in Complex Systems. Sub-headers should be added in the supporting text. In addition, the text should clarify how this section relates to complex systems.

Key Message 18.3. Actionable Knowledge for Complex-Systems Decision-Making. The text supporting this key message is not currently written for broad audiences. The key message does not demonstrate that any systems are “responding effectively” to complex climate

change risks to reduce vulnerabilities. Instead, it addresses how systems are analyzing the risks. The text shows evidence of applications of analytic approaches to understand and manage complex interactions; however, it is not clear how effective these approaches are nor whether their results are being applied.

Additionally, sub-headers should be added in the supporting text. The term “megapolises” should be defined in text for broad audience comprehension (Box 18.3).

Key Message 18.4. Knowledge Gaps and Principles for Managing Complex Systems. The Committee suggests adding sub-headers in the supporting text.

Comments on Traceable Accounts

The purpose of traceable accounts is to describe how the authors arrived at their confidence and likelihood statements in each key message, thereby making the chapter findings credible and transparent. Overall, the traceable accounts in this chapter are of uneven quality and the Committee suggests following the recommended guidance for traceable accounts provided in Chapter 2 of this report. Specifically, the traceable account for Key Message 18.1 refers to the main text instead of outlining the evidence base and uncertainties using citations in detail and dedicates most of its space to describing the development of a figure, which is not the purpose of the traceable accounts section. Similarly, the traceable account for Key Message 18.3 makes broad statements about the literature without specifics and describes the development of figures and boxes. Confidence statements in the key messages lump together multiple claims, and the description of confidence and likelihood in the traceable accounts should elaborate on why the designations are made, particularly from Key Message 18.1. Because the traceable accounts section is lacking citations, this chapter does not identify and provide sufficient context for the embedded content in the traceable accounts section.

Chapter authors should revise the traceable accounts to demonstrate *which* references support *each* confidence and likelihood statement under each key message. The traceable accounts for each key message should include all of the citations provided in the supporting text, should be written at a more technical level than supporting text, and chapter authors should include any technical details and/or key omissions not discussed in the supporting text.

Comments on Graphics and Boxes

Generally, the figures and boxes are well done, though some are too abstract, and figure captions need work to stand on their own as readers may only look at the figures and/or boxes. Self-contained descriptions of what the figures show are needed, including context in the text that refers to the figures. To be successful in illuminating how to understand all of the complexities, the captions should show audiences how to read the figures within context. There is an opportunity for figures in this chapter to better illustrate how complex relationships across systems, peoples, and other non-climate stressors affect vulnerability to climate change.

Figure 18.2 is excellent. More figures like this that help simplify the complexities explained would enhance this chapter. On the other hand, Figure 18.4 is quite abstract.

This chapter makes good use of boxes, which connect themes through real-world examples. Box 18.1 is a nice story to illustrate the concepts in the chapter, whereas Box 18.3 seems more like report text rather than a specific case example. Box 18.3 could also better connect with and cross-references Chapters 19 (Economics) and 31 (Adaptation). Box 18.2 is

timely; however, it references the Camp Fire of 2018 as a case study—well before COVID-19 appeared. There were plenty of 2021 and 2022 fires in California that packed people into evacuation centers. These could be used as more recent examples that directly intersect with COVID-19. For these boxes specifically, the Committee also suggest cross-referencing the relevant focus features, such as Focus on Western Wildfires and Focus on COVID-19, as appropriate.

Additionally, it may be appropriate to create a box about the history and value of the recent advance in the creation of “Chief Resilience Officer” positions around the country.

Comments on Equity and Justice

Equity and justice issues are well integrated in the introduction and throughout the chapter, and overall, the Committee commends this chapter’s strength on data justice and governance issues. Specifically, the Committee appreciates how Key Message 18.2 articulates how historical and contemporary policies make certain groups more vulnerable to direct and indirect climate impacts and clearly identifies research gaps with respect to vulnerability. However, given the inherent connections this chapter has with other chapters, there is an opportunity to better connect with and cross reference equity and justice issues raised in a number of other chapters including Chapter 19 (Economics), among others, benefiting both the chapter as well as the report as a whole.

Comments on Literature Cited

This chapter cites papers from well-respected journals and agencies, many of which were published since NCA4. Additionally, the Committee appreciates how the authors frequently referenced NCA4 in this chapter rather than reproducing information.

CHAPTER 19: ECONOMICS

Summary

The Committee commends the new and valuable addition of Chapter 19 (Economics) as a standalone chapter in the draft NCA5 report. Overall, Chapter 19 (Economics) is a standout chapter that is carefully and precisely written to accurately reflect the current state of knowledge with regard to the inherent connection between climate change and the economy, and it adequately meets the requirements of Section 106 of the GCRA. The language is clear, concise, and accessible to the widest possible audiences (as defined in Chapter 2 of this report), which provides credibility and transparency to the findings. Additionally, the effective use of traceable accounts in this chapter could be used as a model for other chapters throughout the report.

The Committee does, however, offer some minor suggestions for improvement. While Chapter 19 (Economics) does a comparatively exemplary job of cross-referencing other chapters, there are additional opportunities to link with other chapters and focus features, which would help emphasize the inherent connection between the economy and all chapters included in NCA5. Specifically, pointing to examples within other chapters with modest explanations would demonstrate how economics informs understanding of the diversity of projected regional and

sector impacts. Additionally, the Committee highlights a few topics that should be noted. For example, the market disturbances associated with a sudden event such as the collapse of the West Antarctic Ice Sheet. These disturbances include the supply chain risk through the distribution process, which the Securities and Exchange Commission (SEC) reports as “material risk” to potential stockholders. Topics such as inequitable impacts of climate change and climate change impacts on recreation could also be more comprehensively assessed.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction for this chapter is concise, well written, and provides the appropriate background and context on economics as it relates to climate change and the three key messages presented. However, the introduction should also mention which topics are not covered in the chapter (e.g., economics of mitigation).

Comments on Key Messages, Supporting Information, and Traceable Accounts

The key messages are clear, consistent, and written at the appropriate technical level for the intended audiences. The Committee commends the authors for their use of appropriate language, short sentence structure, and the inclusion of confidence/likelihood statements to support each claim. Additionally, the titles of each key message are appropriately concise and informative, and the traceable accounts are exemplary. This chapter is a paragon of communicative writing.

Comments on Specific Key Message Language

Key Message 19.1. Climate Change Will Affect the Economy Directly

Climate change directly impacts the economy through increases in temperature, rising sea levels, and more frequent/intense weather-related extreme events (e.g., wildfires, floods, hurricanes, drought), which are expected to generate substantial economic costs in many sectors (*likely, high confidence*). These impacts are projected to be distributed unequally, affecting certain regions, industries, and socioeconomic groups more than others (*very likely, high confidence*). Adaptation can mitigate some impacts by reducing vulnerability to climate change, but adaptation strategies vary in their effectiveness and costs (*medium confidence*).

The Committee suggests that the first sentence of Key Message 19.1 state that climate is currently affecting the US economy because climate-related impacts are already being observed. For example, there is evidence that rising seas have compounding effects with extreme events such as hurricanes as well as more mundane coastal storms. Additionally, extraordinary precipitation events or long periods without rain have caused measurable economic harm, and wildfires have caused catastrophic loss across wide regions of the country.

The Committee commends the chapter authors for including a statement about projected impacts in the key message as future projections are a requirement of the GCRA.

Key Message 19.2. Markets and Budgets Will Respond to Climate Change

Markets are beginning to respond to current and anticipated climate changes, and stronger market responses are expected as climate change progresses (*medium confidence*). Climate risks are projected to change asset values as markets and prices adjust to reflect economic conditions that result from climate change (*very likely, high confidence*). New costs and challenges will emerge in insurance systems and public budgets that were not originally designed to respond to climate change (*high confidence*). Trade and economic growth are projected to be impacted by climate change directly and through policy responses to climate change (*likely, medium confidence*).

The title of Key Message 19.2 is about projected impacts, but the first sentence discusses observed impacts. To reconcile this discrepancy, the Committee suggests rephrasing to say that markets are “expanding their initial responses” instead of “are beginning to respond to.” Some markets, like agriculture, have been responding to observed and anticipated longer-term trends for decades, but these responses are difficult to measure because they are buried in price signals.

Key Message 19.3. Economic Opportunities for Households, Businesses, and Institutions Will Change

Climate change is projected to impose a variety of new or higher costs on most households and to impact their employment, income, and quality of life (*very likely, high confidence*). Climate change will disrupt the economic landscape that businesses face, generating new risks but also creating new opportunities (*likely, medium confidence*). Institutions and governments are expected to see existing programs used more intensively or in new ways as populations cope with climate change, generating new system-wide risks (*medium confidence*). Design, evaluation, and deployment of adaptation technologies and policies will strengthen our national preparedness for climate change (*high confidence*).

Key Message 19.3 states that “climate change will disrupt the economic landscape businesses face.” The Committee finds the word “disrupt” to be too strong and suggests softening the language accordingly to be consistent with the knowledge base. While there is no doubt COVID-19 disrupted markets, there is little evidence that this will lead to widespread disruption.

Comments on Text Supporting the Key Messages

Overall, the text supporting the key messages is very effective. The Committee provides only minor suggestions.

Key Message 19.1. Climate Change Will Affect the Economy Directly. For the text supporting Key Message 19.1, the Committee suggests that the chapter authors provide specific examples of adaptation measures that have been made and associated measurable economic impacts if they exist in the adaptation section.

Key Message 19.3. Economic Opportunities for Households, Businesses, and Institutions Will Change. Regarding economic impacts of climate change and recreation, relevant to the text supporting Key Message 19.3, the Committee suggests providing a more precise discussion about totality of potential climate impacts on recreation. There is a lot of literature on climate change impacts on cold weather recreation, particularly skiing (e.g., Wobus

et al., 2017), however, the chapter lacks literature on the potentially positive effects on warm weather recreation. Some new literature has been published in recent years to fill this gap (e.g., Chan and Wichman, 2020, 2022; Gellman et al., 2022). These studies find that there could be net benefits to annual recreation nationwide. However, the literature has not fully considered the impacts of high heat, increased precipitation, and fire. Additionally, in the section on economic vulnerability and inequality, the Committee suggests noting that many regions and socioeconomic groups are already seeing diverse levels of personal and food insecurity.

Comments on Traceable Accounts

The traceable accounts for Chapter 19 (Economics) provide accurate and sufficient support for the embedded content and are good examples for other chapters and future assessments.

Comments on Graphics and Boxes

In general, the figures should be self-contained, describing in the caption the message of the figure and how to read it. The Committee suggests referencing the recommendation in Chapter 2 of this report for more guidance on enhancing figures.

Figure 19.1 is informative; however, the data are not traceable to individual studies making the figure difficult to reproduce and indicating a level of original synthesis. It would be beneficial if the data used to create this figure were clearly traceable to individual studies, for example, the way Figure 19.2 uses different panels to trace back to individual studies. If original analysis or synthesis was done to produce this figure, a description of this analysis should be included in the figure caption.

Figure 19.2 is not particularly communicative. Specifically, Figure 19.2 could better emphasize the connection to environmental justice, and it would be beneficial to cross-reference Chapter 20 (Social Systems and Justice).

Figures 19.3 and 19.4 are particularly communicative. However, the caption of Figure 19.4 should include data sources or at least mention the sources of the figures.

Table 19.1 is particularly instructive at displaying the range of direct effects across a breadth of examples. Chapter authors could consider breaking the table into smaller tables, by sections, so it is less overwhelming. Additionally, the table conflates RCP4.5 (~2.7°C median warming) with 2°C warming, and RCP8.5 (~4.5°C median warming) with 3°C warming; these are not identical scenarios and distinctions should be made clearer in the table. The icons in the table would be more helpful in conveying information if they were larger and easier to see and if a key was provided to define the icons. When multiple scenarios are used in the economic estimate column, consider putting each scenario estimate on a separate line, or split the cell horizontally, so it is easier to read the numbers. Finally, the phrase “Relocating Native Alaskan communities” should read “Relocate Alaska Native communities.”

Box 19.1 could add specific examples to make the box tell a concrete story that is less abstract.

Comments on Equity and Justice

The authors should provide some equity- and justice-related framing in the introduction. Specifically, the different dimensions of equity (distribution of benefits and burdens, procedural,

recognitional, and intergenerational equity) as they relate to economics should be integrated. The Committee identified a number of gaps relating to the discussions of equity and justice across Chapter 19 (Economics), including the health and economic costs of climate change and mitigation that are fundamental to the improvement of human health and well-being, such as the economics of heat mortality and economics of the transition to zero-carbon economies; costs and health impacts from air pollution and how that is projected to change with improved air quality; investment or incentives for fossil fuel extraction; employment in low-carbon and high-carbon industries and how this can vary across populations; the economic and financial dimensions of public health and climate change, which are essential to any comprehensive mitigation and adaptation efforts; the social cost of carbon and distribution equity; and the economic aspects of intergenerational equity. The Committee suggests that many of these topics be integrated into the subsection “Economic Vulnerability and Inequality” under Key Message 19.1 and topics focused on investments and employment be integrated into Key Message 19.3. Equity and justice issues on air quality and health could be succinctly mentioned by cross referencing Chapters 14 (Air Quality) and 15 (Human Health). Additionally, the Committee suggests incorporating or at least mentioning the White House Council on Environmental Quality Climate and Economic Justice Screening tool in the chapter (CEQ, 2023). The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible. Finally, specific gaps in equity- and justice-related literature with respect to the chapter focus should be noted.

Comments on Literature Cited

This chapter appropriately reflects the knowledge base, with a focus on publications since NCA4, however, there are a few additional references provided in this review the Committee suggests the authors include to best support the key messages. In particular, the Committee suggests citing more literature published after NCA4.

Other Recommended Changes

The economics of mitigation is a critical omission from this chapter. The Committee suggests including this important topic or providing an explanation for why it is not included in the chapter. The chapter would also benefit from the mention of the potential for market disturbances associated with a rapid global SLR of more than a foot in less two decades. The US Federal Reserve Board (FED) raised this risk in Box 4 of its November 9, 2020, Financial Stability Report (FED, 2020), wherein they warned about risk of “abrupt repricing of assets” and the need to provide information to help markets reflect such risks in asset prices. The chapter could reference Chapters 2 (Climate Trends), 3 (Earth System Processes), or 9 (Coastal Effects) concerning risks of high SLR. The Committee also suggests that chapter authors consider the new Strategy to Develop Statistic for Environmental-Economic Decisions,¹⁵ which is intended to quantify nature’s contribution to the economy for the first time and serve as a tool for decision making.

Additionally, this chapter should reference the Focus on Risks to Supply Chains regarding how enhanced climate risk reporting to financial markets can help abate climate

¹⁵ See <https://www.whitehouse.gov/wp-content/uploads/2023/01/Natural-Capital-Accounting-Strategy-final.pdf>.

change risks. See, for example, WRI/WBCSD (2011) regarding reporting rules on emissions from companies as well as from upstream and downstream supply chains.

CHAPTER 20: SOCIAL SYSTEMS AND JUSTICE

Summary

The Committee commends the inclusion of this new chapter in the draft NCA5 report. The chapter provides six key messages within the interdisciplinary research of social sciences and climate change. These key messages relate to human understanding; human drivers; communication, engagement, and governance of climate change; adaptative strategies of migration; and just transitions. The chapter integrates equity and justice principles consistently throughout the text. The principles of inclusion and justice could be better addressed by expanding the discussion of Indigenous peoples to include all marginalized populations. Overall, the chapter is written using highly technical language making it difficult for general audiences to follow and includes many statements that could be interpreted as policy prescriptive, which are not appropriate for NCA5.

Additionally, the key findings are inconsistent and unclear. Therefore, the Committee suggests revising the chapter with a clearer message for the intended audiences, as defined in Chapter 2 of this report, consistent with the state of knowledge. For these reasons, this chapter does not meet the requirements of Section 106 of the GCRA as written.

A noticeable absence in this chapter—which should assess climate change-related social science findings—is research specifically geared toward helping policy makers to determine which regions and communities are disadvantaged. One standout resource, which uses secondary data to assess resilience and social vulnerability to hazards and risks, is the BRIC Index. These tools are mentioned in Chapter 11 (Agriculture, Food Systems, and Rural Communities), but given their relevance, the Committee suggests they be presented in this chapter and then referenced by the other chapters.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction sufficiently defines relevant terms for the chapter, but otherwise, as written, it does not provide adequate, relevant context or background information that would be useful when reading the chapter. For example, while the introduction begins by stating that other chapters discuss environmental justice, and this chapter will focus on social systems, it ends with an explanation of environmental justice and an outdated framework on dimensions of environmental justice. It is possible the chapter authors intended to use these dimensions of justice as a framework for delineating justice analysis on the presented social systems, but if so, that should be clearly stated and integrated into the chapter. The Committee also suggests the introduction mention fields within social sciences doing work relevant to this chapter (e.g., sociology, social work, geography, policy, psychology, science communication).

Comments on Key Messages, Supporting Information, and Traceable Accounts

The key messages and supporting text could be written at a more appropriate technical level for broader accessibility. In addition, all key messages only have confidence statements but not likelihood statements, which should be added if there is quantitative evidence to support any of the claims.

Comments on Specific Key Message Language**Key Message 20.1. How People Know and Think About Climate Change**

People's social positioning, histories with their environments, and cultural background help determine how they interpret and experience climate change (*high confidence*), including the relationship between climate change and environmental justice (*high confidence*). Knowledge that exists through diverse forms of expression and practice, and that emerges from distinct social and historical contexts, may produce different insights, which in turn give rise to different adaptation strategies and goals—a potentially important resource in society's response to climate change (*medium confidence*).

This key message could be more informative if it incorporated the intended message as explained in supporting text. The Committee suggests making the title of the key message a more informative statement such as, "Values and Beliefs Influences Understanding of Climate Change."

Comments on Text Supporting the Key Messages

Key Message 20.1. How People Know and Think About Climate Change. A major issue with this key message is that epistemological studies only reveal how people *interpret* climate change rather than what and how people *know* what it is about. For example, Taddicken et al. (2018) demonstrates this distinction in which they measure different dimensions of knowledge and confidence in that knowledge (where epistemology comes into consideration). While this study discusses how to measure knowledge, it demonstrates the vast area of social science research into climate knowledge not presented in the chapter.

The last paragraph in this section could be revised to be less policy prescriptive—particularly the last sentence. The paragraph could lay out the state of the literature instead of making judgments on the state of knowledge. If this paragraph does not in fact support Key Message 20.1, it could be moved to the traceable accounts.

Key Message 20.2. Human Drivers Shape Greenhouse Gas Emissions. The supporting text includes the correct statement on page 20-6, line 31-33 that "Higher emissions generally occur in nations and US states with relatively larger populations and growing urban centers," however the statement omits an additional point in the cited work that population density and urbanization often coincide, and therefore the net effect is unclear (Liddle, 2014).

Key Message 20.3. Governance Influences Risk, Adaptation, and Equity. There is a lack of discussion about the roles and dynamics between federal and non-federal (i.e., state, city, and other subnational entities) governance. The Committee suggests adding this discussion. Additionally, on page 20-7, lines 24-26, the discussion and citations of veto points in US governance could be expanded beyond the citation of Madison (1788).

Key Message 20.5. Federal Policy Is Critical to Just Outcomes When Migration Is Necessary. The text supporting this key message would benefit from a short discussion on “disaster capitalism.” The Committee also suggests giving specific examples of migrations after disasters throughout this section to illustrate the ideas presented. In addition, the Committee suggests adding the discussion of probable future significant outcome of migrating populations out of South and Central America toward the United States in the face of increasing climate-change pressures.

Comments on Traceable Accounts

This chapter does not appropriately identify and provide sufficient context for embedded content nor does this content reflect current scientific understanding. The traceable accounts section lacks citations and does not describe which literature applies to which section, discuss uncertainties in the literature, nor how and why the authors arrived at the confidence and likelihood statements. Additionally, new ideas and literature are introduced throughout the traceable accounts that are not included in the main body of the chapter.

Other chapters mention a stakeholder or public engagement workshop. The Committee suggests a statement about whether or not a public engagement session was held for this chapter in the process description, and if not, the statement should provide an explanation for the decision.

The traceable account for Key Message 20.1 states that the authors concentrate on Indigenous peoples’ knowledge for the sake of simplicity to represent US peoples. This method of assessment is incongruent with the requirements of Section 106 of the GCRA. This is a non-scientific assessment method to generalize one small heterogenous population to the other 90 percent of the greater heterogenous population. Indigenous epistemology presented in the text is incomplete. For example, interpretations of knowledge also include the mythical (e.g., expressed through art, stories, dance), experiential (expressed through sensory information), and spiritual (e.g., expressed through reverence, faith). Additionally, this traceable account does not include any citations.

Comments on Graphics and Boxes

Figure 20.2 is not effective, and the information could be conveyed by adding two sentences to the previous paragraph. The Committee suggests removing this figure to make room for one that is more impactful; however, if it is necessary to include, perhaps the image could be smaller.

Figure 20.3 intends to demonstrate that social systems influence migration, and that climate change may exacerbate inequalities, causing more harm, but planned relocation could increase just outcomes. The message is not well understood through the Bronfenbrenner ecological framework and more recent frameworks have been presented in literature (e.g., McMichael, 2020).

Comments on Equity and Justice

The chapter introduces a number of core concepts that are used throughout the report but are not well-defined such as risk, exposure, and justice. The Committee suggests providing

definitions for these terms either in a glossary (consistent with recommendations made in Chapter 2 of this report), or in the Front Matter, and then using them consistently throughout the report. Consistent with the recommendation in Chapter 2 of this report, this chapter should also include the concept of intergenerational justice. The chapter integrates the principles of equity and justice, and the Committee appreciates the key message dedicated to a just transition. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Literature Cited

Overall, the chapter does not adequately represent the breadth of knowledge on human systems and justice in relation to climate change.

CHAPTER 21: NORTHEAST

Summary

Overall, this chapter meets the requirements of Section 106 of the GCRA, with a few specific exceptions noted below. The key findings in the chapter are clearly stated but unevenly and incompletely supported by the detail and sourcing provided within the chapter. The five key messages inconsistently include both levels of confidence and likelihood and claims of confidence may be conflated with the extent of adoption of actions. The traceable accounts briefly and concisely address key uncertainties and knowledge gaps underlying the findings; however, many important uncertainties are not defined in the text supporting the key messages. The Committee appreciates that the chapter prioritizes newer literature (since NCA4), and that the supporting text includes citations after each assertion. However, the findings are not documented well in the traceable accounts section. The traceable accounts require revisions to include citations and more details about how and why confidence and likelihood were determined based on the literature.

The chapter does contain some technical language that may be difficult for broad audiences to follow. The Committee suggests being mindful of terminology and defining specific terms when introduced in the text. Additionally, the term “mitigation” is used interchangeably with “hazard mitigation,” which is confusing, and the Committee suggests building consistency in terminology across the chapter and the report.

Broadly, this chapter would benefit from more attention to agriculture, given its preponderance in the Northeast. For example, USDA maintains a climate hub focused on the northeastern United States. Additionally, there are many opportunities to provide more attention to climate impacts on transportation, human health and welfare, and human social systems without significantly increasing the wordcount by referencing the associated national chapters. This approach would be especially relevant for coastal areas since impacts of climate change on coastal communities are not covered in Key Message 21.2.

This chapter succeeds in analyzing current trends in climate change in the Northeast and projecting those trends to mid-century and the end of the century. However, it does not project 100 years in the future, as outlined in Section 106 of the GCRA, but tends to end at the year 2100. This chapter presents strong and powerful messages on impacts and adaptation as well as

projections. However, while the chapter focuses on impacts and adaptation, it omits an important detailed discussion on mitigation. For example, the Regional Greenhouse Gas Initiative (RGGI) is not mentioned when mitigation leadership is discussed.

Finally, the chapter authors note that the findings presented in the corresponding chapter of NCA4 remain valid and that the region is making important progress both in adaptation and mitigation efforts and in many ways leads the United States in these efforts. The Committee commends the authors for referencing NCA4 so as not to repeat information, and for focusing the key messages in the draft NCA5 report on actions under way to address issues identified in NCA4. The key messages in the chapter also stress how these efforts increasingly reflect equity and justice concerns identified in NCA4. What is new in the draft NCA5 report is a clearer focus on the need for adequate funding to sustain and expand such efforts as climate continues to change and stresses accumulate.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introductory text to this chapter provides appropriate context for the discussion that follows. It is well written at an appropriate technical level for broad audiences. Excellent prose explains which states and tribal entities are included in the northeast region and its economic and geographic variety. Readers get a brief background and context on the northeast and its relevance to climate change.

The introduction asserts that much of what was in NCA4 is still true, begging the question “what is not?” Although it mentions additional points, it is not clear these are all new knowledge since NCA4 since the literature cited includes some in the NCA4 window. It implies that the chapter will cover both adaptation and mitigation, although the former is emphasized. Otherwise, it does not indicate what it will not cover. It makes no effort to define scientific terms where they are used (e.g., “compounding threats”).

Comments on Key Messages, Supporting Information, and Traceable Accounts

With the exceptions noted elsewhere in this review, the key messages in this chapter reflect the current understanding of observed and projected impacts of climate change in the Northeast as well as the challenges, opportunities, and ways to address risk directly. The titles of the key messages are well written as short, informative statements, which can be a model for other chapters. What is missing is the understanding that mitigation is a means to address risk at a more fundamental level. The opportunities to convey the importance of mitigation and review the relevant findings of the literature on this topic that postdate literature included in NCA4 are mostly missed. Relatedly, there is limited discussion of how climate change is producing impacts in this region that make mitigation more challenging or countervail efforts to reduce emissions. Examples range from increased use of air conditioning to decreased CO₂ uptake in ocean waters to disrupted forests and soils. Such issues can be brought to attention in part by cross-referencing other chapters as appropriate.

The key messages generally are written in a consistent and appropriate way and reflect supporting evidence very well, but the text does include some jargon that could be simplified.

All key messages present confidence metrics. However, likelihood is reported only in Key Message 21.3, and should be added to other key messages if there is quantitative evidence to support the claims being made.

Key Messages 21.1 and 21.2 are emphasized more than the other three key messages. This apparent imbalance in focus impedes the support and integration of ideas across the key messages. While Key Messages 21.1 and 21.2 are many pages long with careful documentation, the supporting text for Key Message 21.3 is shorter and less well-sourced. The text supporting Key Message 21.4 relies on a table to convey much of the information, but the ideas are poorly communicated by providing a recitation of facts with little integration.

Comments on Specific Key Message Language

Key Message 21.1. Impacts from Extreme Weather Events and Chronic Stress are Driving Responses

People in the Northeast continue to be confronted with extreme weather, most notably extreme precipitation, which has caused problematic flooding across the region (*very likely, high confidence*). In response, adaptation and mitigation efforts, including nature-based solutions, have increased across the region (*high confidence*), with a focus on emissions reductions, carbon sequestration, and resilience building (*medium confidence*).

The first sentence of this key message should emphasize the extreme weather to the region rather than the people. As currently written, the first sentence could imply that the topic is mental stress, so the Committee suggests clarifying this sentence by removing “people” and starting with “The Northeast continues...” Additionally, the final sentence of this key message, “In response...” is unnecessarily vague but removing reference to “including nature-based solutions” might clarify and tighten the language. Adaptation and mitigation are both mentioned in this key message with a heavy emphasis on mitigation in the last sentence but the text that follows mainly reflects adaptation measures (mainly nature based). The Committee suggests expanding on mitigation efforts or possibilities in the region.

Key Message 21.2. Ocean and Coastal Impacts Are Driving Adaptation to Climate Change

The ocean and coastal habitats in the Northeast are experiencing changes that are unprecedented in recorded history, including ocean warming, heatwaves, sea level rise, increases in heavy precipitation events, and ocean acidification (*high confidence*). Changing ocean conditions are causing significant shifts in the distribution, productivity, and seasonal timing of life-cycle events of living marine resources in the Northeast (*high confidence*). These impacts have spurred adaptation efforts such as coastal wetland restoration and changes in fishing behavior (*medium confidence*).

Overall, this key message is well written and informative, however, the Committee suggests including likelihood statements if possible. Additionally, it is not always clear which part of the sentences the confidence statement is referring to, and the Committee suggests carefully providing confidence and/or likelihood for each assertion.

Key Message 21.3. Disproportionate Impacts Drive Advocacy and Policies

Extreme heat, storms, flooding, and other climate-related hazards are causing disproportionate impacts among historically marginalized communities in the Northeast, including racial and ethnic minorities, people of lower socioeconomic status, and older adults (*very likely, very high confidence*). These communities tend to have less access to health care, social services, and financial resources, and to face higher burdens related to environmental pollution and preexisting health conditions (*very likely, high confidence*). Social equity objectives are prominent in many local-level adaptation initiatives, but the amount of progress toward equitable outcomes remains uncertain (*very likely, high confidence*).

The Committee appreciates that this key message addresses equity (disproportionate impacts), but the wording of the last finding, “the amount of progress toward equitable outcomes remains uncertain (*very likely, high confidence*)” as stated may be misinterpreted as progress is very high. Perhaps rather than “uncertain” the authors mean to say “uneven.”

Comments on Text Supporting the Key Messages

Key Message 21.1. Impacts from Extreme Weather Events and Chronic Stress are Driving Responses. This key message is discussed in four pages packed with up-to-date references. The Northeast is heating faster than most regions of North America, and extreme heat events cause more deaths each year than all other extreme weather events combined. This should be reflected in a more balanced summary of extreme precipitation and extreme heat impacts. The chapter authors may be able to tighten up some of the paragraphs addressing flooding and add in some perspectives on implications for people. Additionally, while the text supporting this key message does mention increased pest ranges, the Committee suggests briefly expanding the discussion on the impact of invasive insect species, especially with regard to climate-mediated migration or dispersal, in the context of forest health, given that it is such a prevalent issue in the Northeast.

Key Message 21.2. Ocean and Coastal Impacts Are Driving Adaptation to Climate Change. The discussion on this key message is unbalanced, with five pages on impacts and only one page on projections. Similarly, this key message is somewhat short on adaptation examples, which appear mostly as citations. The Committee suggests the chapter authors consider shortening the discussion on marine biological impacts and including more discussion of recent literature on social and economic implications of the impacts cited. The Committee appreciates the example of the positive impact of climate change on blue crabs in the Chesapeake Bay.

The broad statement that acidification “may” exert an impact seems too general, but the details and citations that follow are a great example of how to organize a discussion. The discussion of oxygen loss (page 21-12) lacks explanation for broad audiences and introduces related concepts (added nutrient load) without clearly highlighting the connection. Unlike Key Message 21.1, there is no mention of mitigation as a response to the impacts being observed, although there is ample opportunity to do so for example, when discussing coastal wetland restoration. Also missing is a discussion of how some of these changes (e.g., higher ocean temperatures) worsen the mitigation challenge.

Key Message 21.3. Disproportionate Impacts Drive Advocacy and Policies. This key message presents the issues well and the references provided are useful but are sparser. There are